

Department of Forensic Science

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**CONTROLLED SUBSTANCES
TRAINING MANUAL
OF
FORENSIC SCIENCE**

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1 INTRODUCTION

1.1 Purpose and Scope

- 1.1.1 The purpose of this manual is to provide a uniform coordination of the training of forensic drug chemists employed by the Commonwealth of Virginia. This work is intended to be used in a formal training program that will establish a certain minimum standard of professional competency throughout the statewide branches of the Department of Forensic Science.
- 1.1.2 Certain inherent qualities of drug evidence prohibit the establishment of a rigid set of standard procedures to cover each and every case. Therefore, enough latitude has been given to allow for independent thought and individual freedom in selecting alternative courses of action. Upon completion of this course the trainee will be thoroughly familiar with the options available to handle most pieces of evidence that will be encountered.
- 1.1.3 The sequence in which the tasks are presented in the outline should not necessarily be considered as a mandatory order of instruction. Exposure to legal aspects and testimony will be continuous throughout the training.

1.2 Coordination of the Program

- 1.2.1 The Training Coordinator (TC) will be the Section Supervisor, Group Supervisor, or designee, in each lab.
- 1.2.2 The coordinator will be responsible for the overall training, but may delegate certain duties and blocks of instruction to other chemists.
- 1.2.3 Any inter-laboratory training should be arranged through the appropriate coordinators.

1.3 Training Period

- 1.3.1 The length of the training period is a highly variable matter and will be left to the determination of the Chemistry Program Manager. Certain individuals may require less time than others, depending on experience, education, or learning ability. However, the training period should require a minimum of 6 to 9 months, which is to include successful completion of mock trial(s).
- 1.3.2 The training of a new chemist will be broken into two phases: Marijuana Analysis and Drug Analysis.
- 1.3.3 The first phase, Marijuana Analysis, will ensure that the trainee is qualified to analyze marijuana cases and issue reports. This section will include the successful completion of Sections 2 and 5-9 from this Training Manual and Section 20 (Courtroom Testimony). Completion of Marijuana Analysis should be no later than three months after the trainee has entered the program.
- 1.3.4 The Drug Analysis phase includes the completion of Sections 4, and 10-22 (Section 23 will be completed at the discretion of the Section Supervisor and Program Manager) from this Training Manual.
- 1.3.5 Under the direct supervision of a qualified examiner, the trainee will assist with casework throughout the training period. This will familiarize the trainee with different forms of case evidence, packaging, applied analytical techniques, note-taking, and the technical review process.

1.4 Location of Training

Whenever practical, the bulk of an individual's training will occur in the lab to which they will be assigned.

1.5 Training Goals

The training should culminate so that the trainee has the following:

- The knowledge of the basic chemistry, pharmacology and scheduling of controlled substances
- The knowledge of the principles and practices of forensic analytical chemistry related to the analysis of controlled or commonly abused substances
- The knowledge of the theory and applications of the variety of instrumentation and specialized techniques used to analyze controlled substances
- The ability to perform accurate forensic analysis independently and proficiently
- The ability to skillfully present and defend analytical findings in courts of record
- The ability to perform administrative and technical review of case files

1.6 Instructions to the Trainee

- 1.6.1 The trainee is expected to keep a loose-leaf notebook of information compiled on the *Color Test / TLC Worksheet* (221-F200) for the drug knowns listed in Appendix A. This will be completed during Sections 4, 11 and 12. This notebook will be checked by the TC upon its completion.
- 1.6.2 The written answers to the study questions listed in each section will be used as reference material once the trainee is qualified as an examiner. Therefore, references are to be listed for each answer whenever possible. The completed study questions are to be turned into the TC as scheduled. A list of useful references has been provided in the References sections.
- 1.6.3 References listed as “Required Reading” are required for an adequate understanding of the subject matter. Required readings are designated by section numbers listed after the assignment.
- 1.6.4 The trainee will assist with casework throughout the training, but only under the direct supervision of a qualified examiner.
- 1.6.5 The trainee should provide a weekly written progress report to the TC.

1.7 Instructions to Training Coordinators

- 1.7.1 As previously stated, the intent of the manual is to provide a guide that will ensure each and every trainee of receiving certain basic principles and fundamentals necessary to the complete education of a forensic drug chemist. All of the listed topics must be incorporated into the program. Some of the topics will strongly suggest an order of events and this ranking should be followed. Any significant deviation from the manual must be cleared first with the Chemistry Program Manager.
- 1.7.2 The performance of the trainee will be evaluated during the course of the program. The TC must submit regular written evaluations of the new chemist's progress to the Chemistry Program Manager and Laboratory Director. The coordinator is to discuss this evaluation with the trainee prior to forwarding it to the Chemistry Program Manager. Any relevant comments by either the trainee or coordinator are to be included with the report.
- 1.7.2.1 The report should include both previous accomplishments and future objectives.
- 1.7.2.2 These reports should also include information from mock cases and unknowns given to and analyzed by the trainee. A list of the expected results and the actual results will be included.
- 1.7.2.3 A copy of the report will be placed in the training file.
- 1.7.3 Copies of the completed written examinations should be forwarded to the Chemistry Program Manager as the sections are completed.

- 1.7.4 The TC is responsible for maintaining the Department's training program documentation during the training period. Each section in the chart of the *Controlled Substances Training Worksheet – Examiner* (221-F201) must be initialed and dated upon completion of the specified task. If any task is not completed, for any reason, this must be explained in the training file and approved by the Chemistry Program Manager.
- 1.7.4.1 The contents of the sections may be skipped for previously trained and qualified examiners who have demonstrated to the TC a comprehensive knowledge of the section's subject matter with the approval of the Chemistry Program Manager.
- 1.7.4.1.1 The TC will submit a written recommendation to the Chemistry Program Manager outlining the sections which may be omitted or modified and the justification for doing so.
- 1.7.4.1.2 A copy of the approved recommendation will be placed in the training file.
- 1.7.4.2 Written examination questions for each section will be selected or derived from the study questions by the TC.
- 1.7.4.3 The written examination will be given in a "closed book" format.
- 1.7.5 If the trainee cannot meet the criteria expected of them during the period allowed for training, then steps must be taken to effect appropriate action.
- 1.7.6 Supervised Casework Work-Alongs:
- 1.7.6.1 Prior to handling evidence/performing supervised work-alongs on casework, the trainee shall demonstrate competence through the successful completion of practical exercises or completion of a competency test. The trainee shall be authorized to perform supervised casework tasks within the scope of the associated practical exercise(s), or competency test, following successful completion of the practical exercise(s) or competency test.
- 1.7.6.2 The "Controlled Substances Training Documentation" form (221F-201) or a MFR shall serve to document the aforementioned authorizations by the TC.

1.8 Mock Trials

- 1.8.1 The TC is responsible for ensuring that the trainee is thoroughly prepared for legal questioning. This can be done by a combination of mock trials, prearranged as well as impromptu question and answer sessions, and observation of courtroom testimony given by experienced examiners.
- 1.8.2 The scheduling of practice mock trials is to be done by the TC. These are to be conducted throughout the training period.

1.9 Guidelines for the Final Competency Examinations

- 1.9.1 A competency examination will be conducted following the successful completion of the marijuana and drug analysis blocks of instruction. The case samples will be fabricated and validated per Quality Manual ¶ 19.5.3.2. The competency samples will be made at the direction of the Chemistry Program Manager and shall include both qualitative and quantitative samples. The fabricated case thus serves as a monitor of the trainee's competency in applying techniques and procedures to actual casework samples.
- 1.9.2 Prior to the final mock trial, a technical oral examination of the trainee will be conducted to ascertain the technical knowledge of the individual. Minimally, the Program Manager and TC shall be in attendance. This will be limited to three (3) hours.

- 1.9.3 It is expected that the chemical structures of any drugs and reagents utilized in the final mock case be known and understood by the trainee.
- 1.9.4 After the examination, supervision/management will assess the trainee's performance.
- 1.9.5 The outcome of the examination will be:
- 1.9.5.1 Satisfactory
 - 1.9.5.2 Not satisfactory
 - 1.9.5.2.1 If the panel determines that the trainee's performance was not satisfactory, steps must be taken to effect the appropriate action.
- 1.9.6 A recorded final mock trial will follow the successful completion of the technical oral examination. The Chemistry Program Manager must agree with the selection of all participants for the trial.
- 1.9.7 The atmosphere of the final mock trial will be formal. That is, it will be conducted in the same manner as a real courtroom situation. This includes conduct, protocol, and all other aspects. Answers and explanations are to be delivered as to a lay jury.
- 1.9.8 The final mock trial will not exceed two (2) hours.
- 1.9.9 The role of prosecutor will be assumed by the TC or a designee.
- 1.9.10 There may be two defense lawyers, one of whom must be a qualified drug chemist.
- 1.9.11 The trial may be stopped at any time upon the request of any of the involved parties.
- 1.9.12 After the trial, the Evaluation Committee (EC) will assess the trainee's performance. The EC shall consist of the TC, Section Supervisor (and Group Supervisor, if in the supervisory chain of command), Laboratory Director, and Program Manager.
- 1.9.13 The outcome of the trial will be:
- 1.9.13.1 Satisfactory
 - 1.9.13.2 Not satisfactory
 - 1.9.13.2.1 If the EC determines that the trainee's performance was not satisfactory, steps must be taken to effect the appropriate action.
- 1.9.14 This evaluation will be immediately followed by a short performance critique.
- 1.9.15 The TC will review the recording of the trial with the trainee as soon as possible. Other participants/observers should provide any comments to the TC as soon as possible.
- 1.9.16 Satisfactory performance on the entire competency examination must be achieved before the individual is qualified to perform the duties of an examiner.
- 1.9.16.1 After satisfactory performance of the marijuana technical examination and mock trial, the trainee will be qualified to work cases involving marijuana.
- 1.9.17 The Chemistry Program Manager will complete pages three and four of the *Controlled Substances Training Worksheet - Examiner* (221-F201) as documentation.

1.10 Transition from Trainee to Examiner

- 1.10.1 After the new chemist has successfully completed this training, there follows a period of adjustment. The job of the coordinator is to ensure that this transition from trainee to qualified examiner takes place as smoothly as possible. If the TC is also the chemist's supervisor, it is an easy matter to monitor the work of the new person. If this is not the case, the coordinator will have to work with the person's supervisor to ensure that everything is proceeding satisfactorily.
- 1.10.2 Casework will be introduced stepwise under the close supervision of a qualified senior chemist.
- 1.10.3 All reports must be technically reviewed prior to release by the supervisor or designee(s) for a period of six months.
- 1.10.4 The supervisor, TC, or designee will accompany and monitor the newly qualified examiner to court for the first several cases.
- 1.10.5 The new chemist will be required to evaluate the training program approximately 4-6 months following qualification. The DFS *Training Program Evaluation Form* (100-F121) should be forwarded to the Chemistry Program Manager. The Chemistry Program Manager will review the completed evaluation form and use the information to improve the training of future chemists.

1.11 Training for Forensic Laboratory Specialists

- 1.11.1 Training for Forensic Laboratory Specialists (FLS) within the Controlled Substances Section will be coordinated by the Section Supervisor or designee.
- 1.11.2 The training period is variable and the FLS will incrementally begin working independently on duties where the training segment is complete while continuing training on additional duties. The FLS should be working independently on most tasks after approximately two months.
- 1.11.3 The TC is responsible for maintaining the training program documentation during the training period. Each section in the chart of *Controlled Substances Training Worksheet - FLS* (221-F202) must be initialed and dated upon completion of the specified task. Not all sections may be applicable depending on location. If any task is not completed, for any reason, this must be explained in the training file.
- 1.11.4 Completion of Training
 - 1.11.4.1 The training will be considered complete when the FLS has completed all of the segments, which had been required by the TC.
 - 1.11.4.2 The *Controlled Substances Training Worksheet - FLS* (221-F202) for the FLS training will be initialed and completed for each area assigned by the TC and any other personnel who assisted in the training in accordance with the Department Quality Manual.
 - 1.11.4.3 When the training is complete the TC will notify all Controlled Substances supervisors, the Chemistry Program Manager, the QAC and training records will then be stored in accordance with the Department Quality Manual.
 - 1.11.4.4 If the FLS cannot meet the criteria expected of them during an expected period of time for training, steps will be taken to effect appropriate action.

2 ORIENTATION

2.1 Minimum Requirements for Orientation

- 2.1.1 Introduction to local operating facilities and personnel
- 2.1.2 Assignment of a work/study area
- 2.1.3 Coverage of the following:
 - Quality Manual
 - Departmental Administrative policies
 - Regional Operating Procedures (ROP)
 - Section Procedures Manual
 - Section Training Manual
 - DFS Safety Manual
 - Organization of the Department of Forensic Science
- 2.1.4 Introduction to the technical capabilities of all regional laboratories, to include definitions of the regional boundaries and areas of overlap
- 2.1.5 Explanation of the purpose of the training program including an insight into the course of events and what the trainee is expected to accomplish
- 2.1.6 Explanation of the operation of local, state and federal law enforcement agencies and court systems
- 2.1.7 Clarification of the duties of a forensic drug chemist
- 2.1.8 Introduction to the LIMS system

3 BASIC LITERATURE AND REFERENCES

3.1 This section is intended to introduce the trainee to the pertinent technical literature available. In some instances, it may be helpful to demonstrate the usefulness of certain works. Other pertinent references are listed in the References sections of this manual. The trainee must have a working knowledge of the sources most frequently used, including but not restricted to the following:

- 3.1.1 *United States Pharmacopeia/National Formulary*
- 3.1.2 *Merck Index*
- 3.1.3 *Physician's Desk Reference*
- 3.1.4 *DEA Logo INDEX*
- 3.1.5 Horwitz, *Official Methods of Analysis of the Association of Official Analytical Chemists*
- 3.1.6 Schirmer, *Modern Methods of Pharmaceutical Analysis*
- 3.1.7 Clarke, *Isolation and Identification of Drugs*, Volumes 1, Second Edition and 2, First Edition
- 3.1.8 Florey, *Analytical Profiles of Drug Substances*, Volumes 1 – 20
- 3.1.9 Brittain, *Analytical Profiles of Drug Substances*, Volumes 21-29
- 3.1.10 Moffat, ed., *Clarke's Isolation and Identification of Drugs*, 2nd ed.
- 3.1.11 Moffat, ed., *Clarke's Analysis of Drugs and Poisons*, 3rd ed.
- 3.1.12 Mills, et al., *Instrumental Data for Drug Analysis*
- 3.1.13 Schultes and Hofmann, *The Botany and Chemistry of Hallucinogens*
- 3.1.14 Bailey and Rothblatt, *Handling Narcotic and Drug Cases*
- 3.1.15 Feigl, *Spot Tests in Organic Analysis*
- 3.1.16 *Alphabetical Listing of Drug Products/Distributors* - DEA Publication
- 3.1.17 *Analysis of Drugs* - DEA Publication
- 3.1.18 *Microgram Bulletin* - DEA Publication
- 3.1.19 *Microgram Journal* – DEA Publication
- 3.1.20 McLafferty, F. W., *Interpretation of Mass Spectra*, Second Edition
- 3.1.21 Sunshine, I., *Handbook of Mass Spectra of Drugs*
- 3.1.22 Willard, Merritt & Dean, *Instrumental Methods of Analysis*
- 3.1.23 McFadden, W. H., *Techniques of Combined Gas Chromatography/Mass Spectrometry; Application in Organic Analysis*
- 3.1.24 Beynon, Saunders and Williams, *The Mass Spectra of Organic Molecules*.
- 3.1.25 Watson, J. T., *Introduction to Mass Spectrometry; Biomedical, Environmental and Forensic Applications*

- 3.1.26 *Drug Identification Bible*. Grand Junction, CO: Amara-Chem, Inc., various editions.
- 3.1.27 Silverstein, R. M. et al., *Spectrometric Identification of Organic Compounds* New York: John Wiley & Sons, 1991.
- 3.1.28 Rösner, Peter, et al., *Mass Spectra of Designer Drugs*, Germany: Wiley-VCH, 2007.
- 3.1.29 CND ANALYTICAL REFERENCES
- Amphetamines and related phenethylamines
 - Substituted 3,4-Methylenedioxyamphetamines
 - Cocaine, Local Anesthetics, and common diluents
 - Precursors and Chemicals
 - Methylaminorex and analogs
 - Narcotics
 - Anabolic Steroids
 - Hallucinogens
 - Barbiturates
- 3.1.30 Drozd, J., *Chemical Derivatization in Gas Chromatography*
- 3.1.31 Saferstein, Richard, *Forensic Science Handbook*, Volume II
- 3.1.32 Watson, J.T., *Introduction of Mass Spectrometry*, 3rd Edition
- 3.1.33 *Basic Training Program of Forensic Drug Chemists*, D.E.A. Publication
- 3.1.34 Course Materials from the VCU Drug Analysis courses, including PowerPoint presentations and handouts

4 INTRODUCTION TO DRUGS

4.1 Objectives

- 4.1.1 To familiarize the trainee with different classes of drugs of abuse
- Narcotics
 - Stimulants
 - Depressants
 - Hallucinogens
 - Miscellaneous prescription drugs
 - Cannabimimetic Agents
 - Substituted Cathinones / Research Chemicals
- 4.1.2 To familiarize the trainee with simple pharmacology of the major classes of drugs
- 4.1.3 To familiarize the trainee with the molecular structures of the most commonly abused drugs
- 4.1.4 To familiarize the trainee with the origin and physical form of some of the more common drugs
- 4.1.5 To familiarize the trainee with the sources of information for various controlled substances
- 4.1.6 To familiarize the trainee with the legal aspects of controlled substances, to include scheduling in the Code of Virginia and the Federal Drug Control Act

4.2 Modes of Instruction

- 4.2.1 Self-directed study through reading assignments, study questions and practical exercises

4.3 References

- 4.3.1 *Drug Identification Bible*, Grand Junction, CO: Amara-Chem, Inc., various editions.
- 4.3.2 Goodman and Gilman's *The Pharmacological Basis of Therapeutics*. New York: Pergamon Press. 1990.
- 4.3.3 Shulgin, Alexander. *PIHKAL: Phenethylamines I Have Known and Loved*. Berkeley: Transform Press, 1995.
- 4.3.4 *Drugs of Abuse*, DEA Publication.
- 4.3.5 *Code of Virginia*, "The Drug Control Act" (with emphasis on § 54.1-3401; § 54.1-3443 - § 54.1-3456 and §18.2-247 – §18.2-265)
- 4.3.6 U.S. Controlled Substances Act, Title 21, Chapter 13
- 4.3.7 Ciolino, L. A. et al. "The Chemical Interconversion of GHB and GBL" *Forensic Issues and Implications* *Journal of Forensic Sciences*, 2001, Vol. 46, No. 6, pp. 1315-1323.
- 4.3.8 Bommarito, C. "Analytical Profile of Gamma-Hydroxybutyric Acid (GHB)" *Journal of the Clandestine Laboratory Investigating Chemists Association*, Vol. 3, No. 3, 1993.
- 4.3.9 Chappell, J. S. "The Non-equilibrium Aqueous Solution Chemistry of Gamma-Hydroxybutyric Acid" *Journal of the Clandestine Laboratory Investigating Chemists Association*, Vol. 12, No. 4, 2002.
- 4.3.10 Inaba, D. S. and Cohen, W. E. *Uppers, Downers, All Arounders* Ashland, OR: CNS Publications, Inc., 2000.

4.3.11 Sacco, L.N. and Finklea, K. "Synthetic Drugs: Overview and Issues for Congress". *CRS report*. May 2016.

4.3.12 Drug Abuse Handbook, Ed. Karch S.B., CRC Press, 2010.

4.4 Assignments

4.4.1 Completion of required reading assignments (4.3.4 and 4.3.5)

4.4.2 Practical exercises

4.4.3 Study questions

4.5 Study Questions

4.5.1 Define the following:

- Controlled substance
- Distribution
- Manufacture
- Drug
- Narcotic drug
- Cocaine base
- Hashish and hashish oil
- Anabolic steroid
- Depressant
- Stimulant
- Alkaloid
- Cannabimimetic Agent
- Substituted Cathinone / Research Chemical
- Analog (per the Code of Virginia)
- Substantially similar (as it pertains to drug analysis)

4.5.2 Match the following drugs with their classification and scheduling:

Classifications: AS—Anabolic steroid D—Depressant
 H—Hallucinogen N—Narcotic/Opiate
 S—Stimulant

Drug	Classification	Scheduling
3,4-MDMA		
PCP		
Heroin		
Hydromorphone		
Psilocyn		
Methadone		
Pentobarbital		
Salicylamide		
Codeine		
Nandrolone Decanoate		
Methamphetamine		
Caffeine		
Diazepam		
Cocaine HCl		
Cannabimimetic Agents		

Meperidine		
Phentermine		
Methylone		
DMT		
Oxycodone		
Methylphenidate		
GBL		
LSD		
25I-NBOMe		
Furanyl Fentanyl		
Benzocaine		

4.5.3 List the physiological effects of the following:

- Depressant
- Hallucinogens
- Anabolic steroids
- Phenethylamines
- Opiates
- Analgesics

4.5.4 List the pharmacological actions of the following drug classes:

- Depressants
- Hallucinogens
- Narcotics
- Stimulants

4.5.5 Depressants

4.5.5.1 What is the difference between a sedative and a hypnotic?

4.5.5.2 What is the largest drug group within the depressants?

4.5.5.3 How are barbiturates classified?

4.5.5.4 Draw the general structure of a barbiturate.

4.5.5.5 How are most depressants illegally obtained?

4.5.5.6 Why are the benzodiazepines included with the depressants? Give their general structure.

4.5.5.7 What is chloral hydrate and how is it used?

4.5.5.8 What does synergism mean?

4.5.5.9 Explain the relationship between GHB, GBL and 1,4-butanediol.

4.5.5.10 Describe the equilibrium formed between GHB and GBL in aqueous solutions of various pH values. How does this affect the analysis?

4.5.6 Hallucinogens

4.5.6.1 What medicinal use do hallucinogens have?

4.5.6.2 From what is LSD derived?

- 4.5.6.3 What is the chemical name for LSD?
- 4.5.6.4 What is peyote? Is it controlled?
- 4.5.6.5 What is the scientific name for “magic” mushrooms?
- 4.5.6.6 What is the chemical name for MDA? For MDMA?
- 4.5.6.7 What is the chemical name for PCP? How are the letters of PCP derived from the chemical name?
- 4.5.6.8 What are common precursors and byproducts related to the manufacture of PCP?
- 4.5.6.9 What is the legal use of PCP?
- 4.5.6.10 What are the chemical names for DMT and STP?
- 4.5.6.11 What is the structural similarity between STP and MDA?
- 4.5.6.12 Describe the appearance of the *Salvia divinorum* plant. How is it scheduled?
- 4.5.7 Narcotics
- 4.5.7.1 Define a narcotic according to the Code of Virginia.
- 4.5.7.2 From what plant is opium obtained? How? Where is the major crop grown?
- 4.5.7.3 What is the definition of an opiate?
- 4.5.7.4 What are the two classifications of opium alkaloids and how do they differ?
- 4.5.7.5 How is Heroin derived from opium? Describe the degradation pathway of Heroin.
- 4.5.7.6 How many alkaloids are there in opium and what percentage (by weight) are they? Which is the principal constituent?
- 4.5.7.7 Name the principal narcotic drugs.
- 4.5.7.8 What is the chemical name for heroin? Street names?
- 4.5.7.9 Define and give examples of each:
- Natural opiate
 - Synthetic narcotic
 - Semi-synthetic narcotic
- 4.5.7.10 How are narcotics used or administered?
- 4.5.8 Stimulants
- 4.5.8.1 Name some common stimulants.
- 4.5.8.2 Draw the structure of phenethylamine.
- 4.5.8.3 What are the major uses for amphetamines?
- 4.5.8.4 How is the word “amphetamine” derived?

- 4.5.8.5 Name some amphetamine-related stimulants.
- 4.5.8.6 Describe three different synthesis methods for methamphetamine.
- 4.5.8.7 What is an anorectic drug?
- 4.5.8.8 What are some street names for some commonly encountered stimulants?
- 4.5.8.9 When is cocaine classified as a stimulant? As a narcotic?
- 4.5.8.10 From what plant is cocaine obtained from? Where is the major crop grown? How is cocaine extracted from the leaves?
- 4.5.8.11 How is cocaine base produced from cocaine hydrochloride? How does “crack” differ from “freebase”?
- 4.5.8.12 How are various stimulants used or administered?
- 4.5.9 Miscellaneous
- 4.5.9.1 What is physical dependence and how does it vary from psychological dependence?
- 4.5.9.2 What is meant by tolerance?
- 4.5.9.3 What are some common household items with a high potential for abuse?
- 4.5.9.4 Define the following drug actions:
- analgesic
 - antipyretic
 - antitussive
 - tranquilizer
 - anticholinergic
 - vasoconstrictor
 - antihelminthic
 - diuretic
 - bronchodilator
 - antibiotic
 - vitamin
 - anesthetic
- 4.5.9.5 What is the difference between an antidepressant and a stimulant?
- 4.5.9.6 Name four common tricyclic antidepressants.
- 4.5.9.7 What is the difference between an anabolic steroid and a corticosteroid?
- 4.5.9.8 What is a cannabimimetic agent? How are they classified in the Code of Virginia?
- 4.5.9.9 What is a substituted cathinone? What are some of the common/street names for these substances? How are they classified in the Code of Virginia?
- 4.5.9.10 Explain the process regarding scheduling drug compounds via the Board of Pharmacy expedited process (Regulation 18VAC110-20-322).
- 4.5.10 Define the schedules in the Commonwealth of Virginia and criteria for placing a drug in each.

4.5.11 Describe the following terms as if you were addressing a lay audience or jury panel:

- Stimulant
- Anesthetic
- Hallucinogen
- Cannabimimetic agent
- Substituted cathinone

4.6 Practical Exercises

Using the form in *Color Test / TLC Worksheet (221-F200)*, start a “Drug Known” notebook by using one sheet for each drug listed in Appendix A. It is most helpful to do the tests by drug group so that differences in chemical structure can be correlated to different test results. Fill out the drug name, schedule information, pharmacological information and structure.

4.7 Mode of Evaluation

4.7.1 Written Examination

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5 EVIDENCE HANDLING AND REPORT WRITING**5.1 Objectives**

- 5.1.1 For the trainee to understand the fundamentals of evidence security and report writing
- 5.1.2 To familiarize the trainee with the LIMS system

5.2 Modes of Instruction

- 5.2.1 Demonstration by the TC of evidence handling and report writing
- 5.2.2 Self-directed study through reading assignments and study questions
- 5.2.3 Observation of Evidence Receiving staff during case submission and evidence transfer (including lockbox)

5.3 References

- 5.3.1 *Quality Manual*, Department of Forensic Science (§ 12, 16, and 20)
- 5.3.2 LIMS system manual dfsfile1\shared\FA-v15
- 5.3.3 *Code of Virginia* (§ 19.2-187.01)
- 5.3.4 *Code of Virginia* (§ 54.1-3431)
- 5.3.5 Evidence Handling & Laboratory Capabilities Guide – Controlled Substances (internet)
- 5.3.6 DFS Controlled Substances Procedures Manual, Reporting Guidelines Section

5.4 Assignments

- 5.4.1 Completion of reading assignments (listed references)
- 5.4.2 Demonstration of proper chain of custody practices by the TC
- 5.4.3 Study questions

5.5 Study Questions

- 5.5.1 Explain the parallel chain of custody methods used by the Department.
- 5.5.2 Define a proper seal. How is a seal upgraded?
- 5.5.3 What is the proper way to mark evidence (personnel receiving evidence and examiner)?
- 5.5.4 Who has access to the main evidence storage room? Your personal locker?
- 5.5.5 Who has access to your work area?
- 5.5.6 Describe the procedures for access to your locker in your absence.
- 5.5.7 Explain the lock box procedure.
- 5.5.8 Explain how to handle evidence which also needs a latent print analysis.

- 5.5.9 Explain how to handle evidence which also needs a DNA analysis.
- 5.5.10 When batching, explain how to properly handle samples from multiple cases to prevent cross contamination.
- 5.5.11 Explain how Certificates of Analysis are generated in the Controlled Substances section.
- 5.5.12 Explain how Certificates of Analysis act as *prima facie* evidence.

5.6 Mode of Evaluation

- 5.6.1 Written Examination

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6 BALANCES

6.1 Objectives

- 6.1.1 To familiarize the trainee with the operation of laboratory balances
- 6.1.2 To familiarize the trainee with balance calibration and quality assurance
- 6.1.3 To familiarize the trainee with the recording and reporting of weights in laboratory notes and Certificates of Analysis
- 6.1.4 To familiarize the trainee with the theory and use of Uncertainty of Measurement

6.2 Modes of Instruction

- 6.2.1 Self-directed study through reading assignments, study questions and practical exercises
- 6.2.2 Presentations and demonstrations regarding use of balances by the TC or designee

6.3 References

- 6.3.1 Balance manufacturer's operating manuals
- 6.3.2 DFS Controlled Substances Procedures Manual, Weighing Practices Section
- 6.3.3 DFS Controlled Substances Procedures Manual, Estimation of Uncertainty of Measurement Section
- 6.3.4 NIST Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement results (intranet)
- 6.3.5 A Beginner's Guide to UoM (intranet)

6.4 Assignments

- 6.4.1 Completion of required reading assignments (6.3.2 – 6.3.5)
- 6.4.2 Practical exercises
- 6.4.3 Study questions

6.5 Study Questions

- 6.5.1 Define the following:
 - Accuracy
 - Precision
 - Balance
 - Analytical Balance
 - Certified Weight
 - Tare
 - Trace/Residue
 - Truncate
 - Standard Uncertainty
 - Expanded Uncertainty
 - Root Sum Squares
 - Net Weight
 - Gross Weight

- Static Measurement
- Dynamic Measurement
- Uncertainty of Measurement
- Traceability
- Calibration
- Internal Calibration

- 6.5.2 Explain the quality assurance program for balances in the Controlled Substance's section. How is it documented?
- 6.5.3 If a balance falls outside established guidelines during the weekly QA, what steps must be taken before the balance may be used for case work? How, when, why and by whom are balances calibrated?
- 6.5.4 How are the accuracy and precision of the balances checked?
- 6.5.5 Describe sources of measurement uncertainty with respect to weight determination.
- 6.5.6 Explain the laboratory's uncertainty of measurement policy/procedure as to a jury.
- 6.5.7 What types of weights are used for balance QA? Are they traceable?
- 6.5.8 Discuss the different balances available in your laboratory including the accuracy and minimum/maximum loads for each.
- 6.5.9 What is the difference between the troy and avoirdupois weighing systems? Which one is used for Marijuana analysis? What is the conversion factor used in your analysis scheme?

6.6 Practical Exercises

- 6.6.1 Check the performance of your balances following the quality assurance plan.
- 6.6.2 Check the accuracy and precision of your balances.
- 6.6.3 Explain what an Uncertainty Budget is for an analytical balance. Is it different for a top-loading balance? Do these budgets ever change?
- 6.6.4 Weigh the following objects on your top-loading balance and the analytical balance. Record the weights as in case notes and designate the weight to be reported on a Certificate of Analysis.
- Ten marijuana seeds
 - Weighing paper – various sizes (at least two)
 - Weigh boats – various sizes (at least two)
 - Contents of a sugar packet

6.7 Mode of Evaluation

- 6.7.1 Written examination

7 STEREOMICROSCOPES

7.1 Objective

To make the trainee proficient in the use of the stereomicroscopes used in the laboratory

7.2 Modes of Instruction

7.2.1 Self-directed study through reading assignments and study questions

7.2.2 Demonstrations by the TC or designee

7.2.3 Practical exercises

7.3 References

7.3.1 Microscope manufacturer's operating manual

7.3.2 Saferstein, Richard, Ph.D. *Criminalistics: An Introduction to Forensic Science, Eighth Edition*. Upper Saddle River, NJ: Prentice Hall, 2004, pp. 175-176.

7.3.3 Saferstein, Richard, Ph.D., editor. *Forensic Science Handbook*. Englewood Cliffs: Prentice Hall, 1982, pp. 416-434.

7.4 Assignments

7.4.1 Completion of required reading assignments (7.3.2 and 7.3.3), study questions and practical exercises

7.5 Study Questions

7.5.1 Describe the principal parts of the stereomicroscope and the function of each.

7.5.2 How does the stereomicroscope differ from other compound microscopes?

7.5.3 How is the magnification determined? What magnification ranges are used in the laboratory?

7.5.4 What is the laboratory's quality assurance procedure for the microscopes?

7.6 Practical Exercises

7.6.1 Record observations of the following:

7.6.1.1 Baking soda

7.6.1.2 Table salt

7.6.1.3 Ground marijuana leaf material

7.7 Mode of Evaluation

7.7.1 Written examination

8 MARIJUANA**8.1 Introduction**

- 8.1.1 Because the analysis of marijuana is relatively simple and somewhat different from the analysis of other drugs, it is advantageous to teach the trainee this procedure first. It not only gives the new chemist a feeling of accomplishment but also provides the coordinator with an opportunity to view the trainee's analytical laboratory skills.

8.2 Objectives

- 8.2.1 To familiarize the trainee with the protocol for marijuana analysis
- 8.2.2 To make the trainee proficient in the analysis and identification of marijuana

8.3 Modes of Instruction

- 8.3.1 Self-directed study through reading assignments and study questions
- 8.3.2 Work-alongs and examiner shadowing
- 8.3.3 Practical exercises

8.4 References

- 8.4.1 Moffat, A.C. editor *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986, pp. 423-425.
- 8.4.2 Nakamura, George R. and Thorton, John I. "The Identification of Marijuana" *Journal of the Forensic Science Society*, (1972), 12, 461.
- 8.4.3 Virginia Department of Forensic Science Controlled Substances Procedures Manual, Marijuana Section
- 8.4.4 AOAC Methods (1980) Section 40.012 and 40.013 (page 686)
- 8.4.5 *Drugs of Abuse*, DEA Publication, 1997.
- 8.4.6 Bailey, K. "The Value of the Duquenois Test of Cannabis – A Survey" *Journal of Forensic Sciences*, (1971), 24(4), pp. 817-841.
- 8.4.7 Nakamura, G. R. "Forensic Aspects of Cystolith Hairs of Cannabis and Other Plants." *Journal of the AOAC*, (1969), Vol. 52, No. 1, pp. 5-16.
- 8.4.8 Bureau of Narcotics, *Marihuana, Its Identification*, United States Government Printing Office, Washington, 1948.
- 8.4.9 Nakamura, George R. and Thorton, John I. "The Forensic Identification of Marijuana: Some Questions and Answers". *DEA* (1973), Vol. 1, pp. 102-112.
- 8.4.10 Smith, R.N. "Brief Note on the Response of Some Essential Oils and Extracts of Vegetable Origin to the Duquenois-Levine Test for Cannabis." *Journal of the Forensic Science Society*, (1974), 14, pp. 191.
- 8.4.11 Waller, C.W. The Chemistry of Marijuana. *Proc. West. Pharmacol. Soc.*, (1971), 14, pp. 1-3.
- 8.4.12 Grinspoon, L. "Marijuana" *Scientific American*, (1969), Vol. 221, No. 6, p. 17.

- 8.4.13 Pitt, C. G., et al. "The Specificity of the Duquenois Color Test for Marihuana and Hashish" *Journal of Forensic Sciences*, 1972, p. 693.
- 8.4.14 Code of Virginia, [§ 19.2-188.1](#). Testimony regarding identification of controlled substances and associated regulations.
- 8.4.15 Jacobs, A.D., Steiner, R.R., Detection of the Duquenois-Levine chromophore in a marijuana sample, *Forensic Science International*, 2014.
- 8.4.16 *Drug Identification Bible*. Grand Junction, CO: Amera-Chem, Inc., various editions.
- 8.4.17 Hughes, R.B., Kessler, R.R., Increased Safety and Specificity in the thin-Layer Chromatographic Identification of Marihuana, Technical Note, *Journal of Forensic Sciences*, 1979.
- 8.4.18 Forrester, D., *The Duquenois Color Test for Marijuana: Spectroscopic and Chemical Studies, Volume One*, 1997.
- 8.4.19 Clarke, R.C., *Marijuana Botany. An Advanced Study: The Propagation and Breeding of Distinctive Cannabis*, 1981.
- 8.4.20 Mechoulam, R., Marihuana Chemistry, 1970, *Science*.
- 8.4.21 Razdan, R.K., *Recent Advances in Chemistry of Cannabinoids, Progress in Organic Chemistry*, Vol 8).

8.5 Assignments

- 8.5.1 Completion of required reading assignments (8.4.2, 8.4.3, 8.4.7, 8.4.13, 8.4.14 and 8.4.15)
- 8.5.2 Practical exercises
- 8.5.3 Study questions

8.6 Study Questions

- 8.6.1 What is the definition of marijuana as per the Code of Virginia? How is it scheduled?
- 8.6.2 Compare and contrast the definition from the Code of Virginia to that in the Federal Controlled Substances Act. What are the possible analytical implications?
- 8.6.3 Describe the appearance of a mature marijuana plant.
- 8.6.4 What is the derivation of the word "marijuana"?
- 8.6.5 Describe the appearance of marijuana seeds. Are they a positive result for any of your tests?
- 8.6.6 What is sinsemilla and how is it grown?
- 8.6.7 What is hemp? What are the legal issues surrounding hemp? Are there any analytical requirements?
- 8.6.8 What is the taxonomic name for marijuana including family, genus and species?
- 8.6.9 What parts of the plant contain THC (include average percentage)?
- 8.6.10 Define "agronomic variety" and differentiate between *Cannabis sativa*, *Cannabis ruderalis*, *Cannabis indica* and *Cannabis americana*.

- 8.6.11 Define “dioecious” and relate to Cannabis. Include the different morphological characteristics between the two.
- 8.6.12 What is the function of the resin found on the plant?
- 8.6.13 Define and discuss the differences between hashish, hash oil, butane honey oil and marijuana “butter” including preparation, schedule, and analysis.
- 8.6.14 What is the pharmacological classification of marijuana?
- 8.6.15 Define the following:
- cannabinoid (include structures of the three “major” cannabinoids)
 - alkaloid
 - cis and trans isomers
 - optical isomers
 - parahexyl
 - synhexyl
 - dronabinol
- 8.6.16 What factors influence the relative amounts of cannabinoids present in marijuana? Are the cannabinoids acidic or basic? Polar or non-polar? Chemically, can any of the cannabinoids break down or be converted into THC? Does THC break down?
- 8.6.17 What are the two numbering systems for cannabinoids in use today? Draw THC and show how these numbering systems differ. Which is utilized in the Code of Virginia?
- 8.6.18 What types of isomers are Δ^9 -THC and Δ^8 -THC? Which is the more stable?
- 8.6.19 Is d- or l-THC the naturally occurring isomer?
- 8.6.20 What information is gained and noted from the macroscopic and microscopic examinations of marijuana samples?
- 8.6.21 Describe cystolithic hairs and glandular hairs including characteristics and locations found on marijuana. What magnification is needed to view these hairs under a microscope?
- 8.6.22 Describe the HCl test including when to perform it and what information is gathered.
- 8.6.23 Discuss any other plants which have cystoliths including how to differentiate them from those found on marijuana such as:
- *Humulus japonica*
 - *Humulus lupulus*
 - *Lantana camara*
- 8.6.24 What is a screening test?
- 8.6.25 Describe the Duquenois-Levine (D-L) procedure as published by the AOAC and discuss any differences from the procedure used in the Department. Include any references which validate the DFS procedure. How does the D-L differ from the Modified Duquenois Test and Rapid Modified Duquenois Test? Include any false positives that may occur.
- 8.6.26 What causes the purple color obtained with the Duquenois reagent and marijuana? What determines whether this product is soluble in the chloroform? Describe/draw a probable reaction mechanism.

- 8.6.27 Describe how Pitt used a spectrophotometer to evaluate colors produced by the D-L test. Is this necessary?
- 8.6.28 Define thin layer chromatography (TLC) including how the test is normally performed. Explain the chemical basis of TLC covering the following topics as they pertain to the analysis of marijuana:
- Types of chromatography
 - Different stationary phases
 - Interactions among the stationary phase, mobile phase and solute, including consideration of equilibrium
 - Influences on chromatography/separation by stationary phase thickness, temperature, humidity, molecular weight, gravity, polarity of mobile phase
 - Explain any and all intermolecular forces which may be at work.
- 8.6.29 Describe the chromatography plates used in the lab including the purpose of each component. Why is silica generally preferred over alumina?
- 8.6.30 Define the following chromatography terms as related to TLC:
- R_f
 - solvent front
 - elutropic series
 - theoretical plate
 - resolution
 - chromophore
- 8.6.31 What standards are used with marijuana TLC analysis and to what level have they been confirmed?
- 8.6.32 What mobile phase(s) are preferred for marijuana analysis? Include any references which validate the DFS procedure.
- 8.6.33 What are Fast Blue B and Fast Blue BB? Include their chemical names and the advantages and/or disadvantages of each. Describe the TLC visualization results obtained by either Fast Blue B or Fast Blue BB with the three major cannabinoids.
- 8.6.34 Describe the specificity of the combination of the three tests normally incorporated into the analytical scheme for marijuana analysis (i.e., Microscopic, Thin-Layer Chromatography and D-L). What other tests are available for the analysis of marijuana and when are they necessary?
- 8.6.35 Describe the quality assurance procedures for the D-L reagents and the TLC baths and sprays.
- 8.6.36 What are the detection limits of the three main tests?
- 8.6.37 Define “residue” as it relates to marijuana analysis. Describe an appropriate procedure for analyzing a smoking device containing suspected marijuana residue.
- 8.6.38 Discuss when a THC quantitation is required for case work.
- 8.6.39 Describe the use of field test kits for marijuana for preliminary hearings and trial.
- 8.6.40 Discuss any scenario(s) when the presence of a cannabinoid would be scheduled in the Code of Virginia.

8.7 Practical Exercises

8.7.1 Examine each of the following under the microscope and describe in detail. Do any give a false positive for marijuana?:

- Dry marijuana leaf material
- Sinsemilla
- Marijuana seeds
- Marijuana stems
- Hashish
- Hash oil
- Hops
- Oregano
- Tobacco
- Sage
- Parsley
- *Salvia divinorum*
- Plant material substrate adulterated with Cannabimimetic Agents (chosen by the TC)

8.7.2 Perform Duquenois-Levine tests on the following and describe results. Do any give a false positive for marijuana?:

- Marijuana
- Hashish
- Hash oil
- Patchouli oil
- Oregano
- Parsley
- Coffee
- Hops
- Tobacco
- Olivetol
- Δ^9 -THC
- Cannabinol
- Cannabidiol
- Resorcinol
- *Ribes viburnifolium* (currant) (if available)
- *Myristica Fragrans* (mace) (if available)
- Current Cannabimimetic Agents (chosen by the TC)
- *Salvia divinorum*
- Dragon's Blood incense, if available

8.7.3 Perform TLC analysis of the following using the marijuana bath and the other baths used in the laboratory. Do any give a false positive for marijuana?:

- Marijuana
- Δ^9 -THC
- Δ^8 -THC
- Cannabinol
- Cannabidiol
- Patchouli oil
- Hash oil
- Hops
- Tobacco

- Oregano
- Parsley
- Coffee
- Olivetol
- Resorcinol
- *Ribes viburnifolium* (currant) (if available)
- *Myristica Fragrans* (mace) (if available)
- Current Cannabimimetic Agents (chosen by the TC)
- *Salvia divinorum*
- Dragon's Blood incense, if available

8.7.3.1 Obtain a known marijuana sample from the TC or designee. Extract the marijuana using hexane, methanol and chloroform. Run each on TLC, make a color photocopy the TLC plate and discuss the differences with the TC.

8.7.3.2 Run a marijuana standard in all baths routinely used in the laboratory in duplicate. Spray one plate with acidified Iodoplatinate and the other with Fast Blue B. Make a color photocopy of the TLC plates and discuss the results with the TC or designee.

8.7.4 Obtain mass spectra of the following, noting any major mass spectral differences:

- Marijuana leaf material
- Δ^9 -THC
- Δ^8 -THC
- Cannabinol
- Cannabidiol
- Olivetol

8.7.5 Obtain marijuana seeds from the TC or designee. Germinate the seeds and analyze the young plant using the normal analytical scheme. Note any difficulties or differences between young plants and more mature plants.

8.7.6 Obtain a sample of charred marijuana residue from the TC or designee. Analyze using the analytical scheme listed in the DFS Procedures Manual.

8.7.7 Receive mock cases from the TC or designee. Work these as real cases including the preparation of a Certificate of analysis to be used in mini-mock trials. Keep a log of cases worked and results obtained.

8.7.8 Participate in several mini-mock trials.

8.7.9 Obtain known marijuana from the TC or designee and perform the HCl test for cystolithic hairs.

8.8 Modes of Evaluation

8.8.1 Written examination

8.8.2 Court exercise (mini mock trials)

8.8.3 Technical/Oral session(s)

9 SAMPLING

9.1 Objectives

- 9.1.1 To familiarize the trainee with the concepts of sampling.
- 9.1.2 To instruct the trainee on the sampling procedures in the laboratory.

9.2 Modes of Instruction

- 9.2.1 Self-directed study through reading assignments and study questions
- 9.2.2 Presentations and demonstrations

9.3 References

- 9.3.1 DFS Controlled Substances Procedures Manual, Sampling Section and Physical Identifiers Section.
- 9.3.2 Coulson, Sally A., Ph.D. *et al.*, “How Many Samples from a Drug Seizure Need to Be Analyzed?”, *Journal of Forensic Sciences*, Volume 46, No. 6 (November 2001), pp. 1456-1461.
- 9.3.3 Colon, Maria, B.S., Rodriguez, Gloria, B.S., and Diaz, Ramon Orlando, M.S. “Representative Sampling of ‘Street’ Drug Exhibits”, *Journal of Forensic Sciences*, Volume 38, No. 3 (May 1993), pp. 641-648.
- 9.3.4 Tzidony, Dov, and Ravreby, Mark. “A Statistical Approach to Drug Sampling: A Case Study”, *Journal of Forensic Sciences*, Volume 37, No. 6 (November 1992), pp. 1541-1549.
- 9.3.5 Frank, Richard S., B.S., Hinkley, Sidney W., Ph.D., and Hoffman, Carolyn G., M.A. “Representative Sampling of Drug Seizures on Multiple Containers”, *Journal of Forensic Sciences*, Volume 36, No. 2 (March 1991), pp. 350-357.
- 9.3.6 Shark, Robert E. “Sampling Your Drugs: A User’s Guide”, Virginia Bureau of Forensic Science Technical Brief.
- 9.3.7 Fishel, C. “Validity of Hypergeometric Sampling”, Virginia Bureau of Forensic Science Technical Brief, August 29, 1988.
- 9.3.8 Williams, Sidney, Editor. *Official Methods of Analysis of the Association of Official Analytical Chemists*, 14th edition. Arlington, VA: Association of Official Analytical Chemists, Inc., 1984, p. 668.
- 9.3.9 SWGDRUG Recommendations, 2nd ed. “PART III A - Methods of Analysis/Sampling Seized Drugs for Qualitative Analysis”, current version available.
- 9.3.10 “Guidelines on Sampling of Illicit Drugs for Quantitative Analysis” European Network of Forensic Science Institutes - Drugs Working Group, April 2014.

9.4 Assignments

- 9.4.1 Completion of required reading assignments (9.3.1, 9.3.2, 9.3.5, 9.3.6, 9.3.7, 9.3.9)
- 9.4.2 Study questions

9.5 Study Questions

- 9.5.1 Define the following:
 - Sampling

- Statistic
- Population
- Sample
- Homogeneous
- Heterogeneous
- Aliquot
- Random
- Representative
- Arbitrary
- Selective
- Grab sample
- Sampling without replacement
- Sampling with replacement
- Weight fraction
- Sample selection

- 9.5.2 Define normal distribution, binomial distribution, and hypergeometric distribution. When is each correctly used?
- 9.5.3 What is the purpose of sampling?
- 9.5.4 What physical properties of particles must be considered when sampling powders?
- 9.5.5 What is “sampling error” and what effect does particle size have when sampling particulate matter?
- 9.5.6 What are the advantages and disadvantages of sampling?
- 9.5.7 What is a “composite” sample?
- 9.5.8 What criteria must be used to determine the size of the sample?
- 9.5.9 What are the major deciding factors in how well a sample represents a population?
- 9.5.10 Discuss the purpose of employing the Department’s Administrative sampling plan versus the Hypergeometric sampling plan:
- When and why would you choose to utilize the administrative sampling plan?
 - When and why would you choose to utilize the hypergeometric sampling plan?
 - What is the difference in the conclusion that can be drawn with the two sampling plans?
- 9.5.11 Explain the statistical inference that can be made when the Hypergeometric sampling scheme is employed.
- 9.5.12 Describe the sampling scheme for specimens that must be quantitated.
- 9.5.13 Describe the procedure for sampling and returning residues.

9.6 Modes of Evaluation

- 9.6.1 Written examination
- 9.6.2 Mock case work

10 DRUG ANALYSIS SECTION**10.1 Introduction**

- 10.1.1 This phase of the program will require more time than the previous section. During this block of instruction the trainee must become thoroughly familiar with all of the basic methods available for drug analysis and their applications.
- 10.1.2 At the end of this phase the trainee must not only be competent with these methods of analysis, but also be able to anticipate the reactions of the basic drug groups (narcotics, amphetamines, etc.) to each method. They will also be expected to know the theory of operation of the instruments used, and be able to perform any related routine maintenance on the simpler devices. It is expected that the chemical structures of any drugs and reagents be known and understood.
- 10.1.3 Mini-mock trials and question/answer sessions should be done throughout this period. The trainee will undoubtedly benefit from verbalizing at the end of each section.
- 10.1.4 This phase will include Sections 4 and 10-22 of this manual and culminate with the formal mock trial and technical session.

10.2 Unknown Samples

- 10.2.1 A program of graduated training samples is to be interspersed throughout the following sections.
- 10.2.1.1 The sets of unknowns will become more difficult with successive samples.
- 10.2.1.2 The TC should prepare or direct the preparation of the samples.
- 10.2.1.3 The samples should be prepared so that their identity is known to the TC.
- 10.2.1.4 The final sets of unknowns which will be used for the final mock trial will be prepared by the TC and approved by the Chemistry Program Manager.
- 10.2.1.5 The actual number of training samples submitted to the trainee is left to the determination of the TC.
- 10.2.2 The trainee should receive unknowns which will be presented exactly as if they were real cases. To the extent possible, all of the related paperwork, security, analyses, and report writing will be handled in the same way as an actual submission. Items of paraphernalia should be included from time to time in the samples.
- 10.2.3 After the chemist has submitted the report for each set of unknowns, the TC must review all of the work with the trainee, including any notes, instrumental data, results obtained and report wording. The evidence itself should be checked for proper labeling and handling.

11 COLOR TESTS**11.1 Objectives**

- 11.1.1 To familiarize the trainee with the preparation, storage, and proper handling procedures of color test reagents
- 11.1.2 To make the trainee proficient in the use of chemical color tests
- 11.1.3 To make the trainee aware of the advantages, disadvantages, and limitations of color tests
- 11.1.4 To make the trainee understand the theory of color tests
- 11.1.5 To familiarize the trainee with field test kits and their applications

11.2 Modes of Instruction

- 11.2.1 Self-directed study through reading assignments and study questions
- 11.2.2 Presentations and demonstrations
- 11.2.3 Practical exercises

11.3 References

- 11.3.1 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 4-1 through 4-11
- 11.3.2 Moffat, A. C., editor. *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986, pp. 128-147.
- 11.3.3 DFS Controlled Substances Procedures Manual, Color Tests Section.
- 11.3.4 Johns, S. H., Wist, A. A., and Najam, A. R. "Spot Tests: A Color Chart Reference for Forensic Chemists", *Journal of Forensic Sciences*, July 1979, pp. 631-641.
- 11.3.5 "Methods of Analysis for Alkaloids, Opiates, Marihuana, Barbiturates, and Miscellaneous Drugs." Internal Revenue Service, (Reprinted by the Bureau of Narcotics and Dangerous Drugs, U. S. Department of Justice), rev. 6-67.
- 11.3.6 Feigl, Fritz. *Spot Tests in Organic Analysis*. Amsterdam: Elsevier Scientific, 1966.
- 11.3.7 *U.S. Pharmacopeia National Formulary*, USP XX, 1980.
- 11.3.8 Saferstein, Richard. *Forensic Science Handbook*. Prentice Hall Regents, Englewood Cliffs, NJ; 1982.
- 11.3.9 Virginia Register, 6 VAC 20-220 and *Code of Virginia* § 9.1-102.
- 11.3.10 Kovar, K.A. and Laudszun, M. "Chemistry and Reaction Mechanisms of Rapid tests for Drugs of Abuse and Precursor Chemicals", *United Nations Scientific and Technical Notes*, February 1989. www.unodc.org/pdf/scientific/SCIE6.pdf

11.4 Assignments

- 11.4.1 Completion of required reading assignments (11.3.2, 11.3.3, and 11.3.4)
- 11.4.2 Study questions

11.4.3 Practical exercises

11.5 Study Questions

11.5.1 Where are the recipes for each of the following color test reagents found? List the types of compounds that react with each test, and state what reaction would be observed. For those marked with an “*” note the compound used for QA:

- Marquis*
- Meckes*
- Froehdes*
- Cobalt thiocyanate*
- Ehrlich’s*
- TBPEE
- Dille – Koppanyi*
- Ferric Chloride
- Tannic Acid
- Stannous Chloride
- Sodium Nitroprusside (Feigl’s)

11.5.2 Where can the QA procedures for color test reagents be found? Discuss this procedure.

11.5.3 Describe the mechanisms of the following color tests:

11.5.3.1 Marquis

11.5.3.2 Cobalt thiocyanate followed by stannous chloride

11.5.3.3 Ehrlich’s

11.5.4 Describe the difference between the terms “sensitivity” and “selectivity” as they relate to color tests.

11.5.5 Define the following terms:

- Precipitate
- Complex
- Ligand
- Coordination number

11.5.6 Define “false positive”. Give three examples of false positive color tests.

11.5.7 Define “false negative”. Give three examples of false negative color tests.

11.5.8 Describe the use of blanks pertaining to color tests.

11.5.9 What effect do mixtures have on color test results?

11.5.10 What effect does time have on color test reagents?

11.5.11 Describe the Scott’s test.

11.5.12 What is a flame test and when might it be useful?

11.5.13 Describe as to a jury how a color test is performed, including the purpose and value of the test.

- 11.5.14 Describe the process by which field test kits are approved by DFS for law enforcement use in the Commonwealth?
- 11.5.15 What does DFS approval of a field test kit mean in a legal sense?
- 11.5.16 How can one determine which field test kits have been approved by DFS?
- 11.5.17 An officer calls stating that the field test kit used on a submitted sample indicated the presence of heroin. Your analysis reveals no controlled substances. How might you explain this?

11.6 Practical Exercises and Worksheets

- 11.6.1 Prepare the following reagents and perform all necessary QA and documentation prior to use:

- Cobalt Thiocyanate with Stannous Chloride modification
- Marquis
- Meckes
- Froehdes
- TBPEE (if available)
- Van Urk's and/or Ehrlich's
- Weber Test (for Hallucinogens only)

- 11.6.2 Obtain standards (secondary, where possible) of the substances listed in Appendix A from the TC. Perform the color tests above for each substance and record in the Drug Known notebook. Some color tests may be eliminated for LSD, LAMPA, psilocin, psilocybin and bufotenine per the TC. Save these standards for use in the Thin Layer Chromatography section.

- 11.6.3 Obtain Lithium Carbonate from the TC and perform a flame test (if equipment is available) using the procedure listed in the USP.

11.7 Modes of Evaluation

- 11.7.1 Written examination
- 11.7.2 Courtroom exercise (mini-mock trials)
- 11.7.3 Technical/Oral session(s)

12 THIN LAYER CHROMATOGRAPHY**12.1 Objective**

12.1.1 To familiarize the trainee with the theory and application of thin layer chromatography in drug analysis

12.2 Modes of Instruction

12.2.1 Self-directed study through reading assignments, worksheets, and study questions

12.2.2 Presentations and demonstrations

12.2.3 Practical exercises

12.3 References

12.3.1 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 4-39 through 4-49.

12.3.2 Moffat, A. C., editor. *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986, pp. 160-177.

12.3.3 DFS Controlled Substances Procedures Manual, Thin Layer Chromatography Section.

12.3.4 Randerath, Kurt. *Thin-Layer Chromatography, Second Edition*. New York: Academic Press, 1968.

12.3.5 *Methods of Analysis for Alkaloids, Opiates, Marijuana, Barbiturates, and Miscellaneous Drugs*. Internal Revenue Service, (Reprinted by the Bureau of Narcotics and Dangerous Drugs, U. S. Department of Justice), rev. 6-67.

12.3.6 Stahl, Egon, *Thin-Layer Chromatography*, 2nd ed., Berlin: Springer-Verlag, 1969.

12.3.7 Bauer, Karin, *et. al. Thin Layer Chromatography*, Heidelberg, Germany: EM Science, 1991.

12.4 Assignments

12.4.1 Completion of required reading assignments (12.3.2, 12.3.3), study questions and practical exercises

12.4.2 Review of TLC-related study questions from Marijuana section

12.5 Study Questions

12.5.1 Define the following:

- Chromatography
- Stationary phase
- Mobile phase
- Adsorption
- Absorption
- Elution
- Partition coefficient (K)
- Polarity
- Dipole moment
- Dielectric constant
- Visualizing reagent
- R_f value

- 12.5.2 With respect to TLC plates, what causes “quenching fluorescence”? What chemical properties does a drug need to possess in order to quench fluorescence?
- 12.5.3 What is the general limit of detection of TLC? What factors influence this?
- 12.5.4 What are the recipes for each of the following TLC baths? Outline the general QA procedure for TLC baths.
- 12.5.4.1 TLC1
- 12.5.4.2 TLC2
- 12.5.4.3 TLC3
- 12.5.5 Consider an elutropic series of solvents. How will the polarity of solvents change when they are mixed together?
- 12.5.6 Which drugs fluoresce under long wave UV? What is the difference in wavelength between short and long wave UV?
- 12.5.7 What are the recipes for each of the following TLC visualizing reagents? For what type(s) of drugs are each utilized most effectively? Outline the general QA procedure for TLC sprays.
- Iodoplatinate
 - Dragendorff
 - Potassium permanganate
 - Ehrlich’s
 - Fluram
 - Ceric sulfate
 - Iodine vapors
 - Furfural
 - Mercuric Sulfate / Diphenylcarbazone
 - Ninhydrin
- 12.5.8 Can LSD and LAMPA be separated using TLC?
- 12.5.9 What TLC baths and sprays should be used in the analysis of salvinorin A?
- 12.5.10 Why do spots having a larger R_f value generally have larger diameters than spots with relatively low R_f values?
- 12.5.11 Does sample concentration have an effect on TLC migration? What causes “tailing” and “bearding” and how can they be minimized? What other factors influence an R_f value and its reproducibility? How can these factors be controlled?
- 12.5.12 How can the results of TLC be documented?
- 12.5.13 What is two-dimensional TLC? Why and how is it performed?
- 12.5.14 Explain as to a jury how TLC operates.

12.6 Practical Exercises

- 12.6.1 Prepare a TLC bath and visualizing reagent designated by the TC and perform all necessary QA and documentation prior to use.

12.6.2 Using the standards of the substances listed in Appendix A, perform TLC analysis on each. Record your results in the Drug Known notebook. Do the tests by drug group so that differences in chemical structure can be correlated to different test results. Use the TLC1, TLC2, TLC3 baths and the following TLC sprays:

- KMnO_4
- Acidified Iodoplatinate (may be acidified with an overspray)
- Ceric Sulfate
- Ehrlich's
- Dragendorff (if available)
- Fluram / Long wave UV (if available)

12.6.3 Using the results from Section 12.6.2, answer the following questions:

- Explain the theory of using multiple TLC systems. Use examples from your data in your explanation.
- Discuss the separation effectiveness of TLC taking into account the structure of the molecule, the polarity/basicity of the solvent system and the polarity of the stationary phase. Use morphine and heroin as examples.
- The pairs Methyldone/Ethylone and Morphine/Codeine differ by only one carbon. Explain the differences between separating the two pairs.
- Which bath(s) separate the phenethylamine-type compounds the best?

12.6.4 Obtain a mixture of cocaine base/procaine from the TC. Perform 2-D TLC analysis to separate the components and confirm each by FTIR. Which bath is the best choice when a base determination is necessary? Why?

12.6.5 Obtain standards of GHB, GBL and 1,4-butanediol. Perform TLC using a mobile phase of ethyl acetate and visualize using iodine vapors.

12.6.6 Obtain a sample of salvia and perform the TLC using the procedure outlined in the Procedures Manual.

12.6.7 Obtain standards of ephedrine and pseudoephedrine from the TC or designee. Using the procedure outlined in the Procedures Manual, separate these compounds using TLC.

12.7 Modes of Evaluation

12.7.1 Written examination

12.7.2 Court exercise (mini mock trials)

12.7.3 Technical/Oral session(s)

13 MICROCRYSTAL TESTS

13.1 Objectives

- 13.1.1 To familiarize the trainee with microcrystal tests for drugs
- 13.1.2 To make the analyst proficient in the use of microcrystal tests for the identification of dextromethorphan

13.2 Modes of Instruction

- 13.2.1 Self-directed study through reading assignments, study questions and practical exercises
- 13.2.2 Presentations and demonstrations

13.3 References

- 13.3.1 Clarke, E. G. C. *Isolation and Identification of Drugs, Volumes 1 and 2*. London: The Pharmaceutical Press, 1978, pp. 135-141.
- 13.3.2 Fulton, Charles C. *Modern Microcrystal Tests for Drugs*. New York: Wiley Interscience, 1969.
- 13.3.3 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 4-13 through 4-20.
- 13.3.4 DFS Controlled Substances Procedures Manual, Narcotics Section.
- 13.3.5 Siegel, Jay A., Ph.D. "Forensic Identification of Controlled Substances", in Saferstein, Richard, Ph.D., editor. *Forensic Science Handbook, Volume II*. Englewood Cliffs, N. J.: Prentice Hall, pp. 68-160.

13.4 Assignments

- 13.4.1 Completion of required reading assignments (13.3.1 and 13.3.4), study questions and practical exercises

13.5 Study Questions

- 13.5.1 Describe the three types of microcrystal tests which may be used.
- 13.5.2 What are some of the advantages and disadvantages of microcrystal tests?
- 13.5.3 How can microcrystal tests be utilized to differentiate stereoisomers?
- 13.5.4 How would you document the results of microcrystal tests in your case notes?

13.6 Practical Exercises

- 13.6.1 Perform microcrystal tests for the following drugs:
 - 13.6.1.1 Dextromethorphan

13.7 Mode of Evaluation

- 13.7.1 Written examination

14 GAS CHROMATOGRAPHY**14.1 Objectives**

- 14.1.1 To familiarize the trainee with the theory and application of gas chromatography in drug analysis
- 14.1.2 To familiarize the trainee with the GC instrumentation and software used in the laboratory

14.2 Modes of Instruction

- 14.2.1 Self-directed study through reading assignments
- 14.2.2 Presentations and demonstrations
- 14.2.3 Study questions
- 14.2.4 Practical exercises

14.3 References

- 14.3.1 Moffat, A. C., editor. *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986, pp. 178-200.
- 14.3.2 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 5-31 through 5-47.
- 14.3.3 DFS Controlled Substances Procedures Manual, Gas Chromatography Section.
- 14.3.4 Stafford, David T., Ph.D. "Forensic Capillary Gas Chromatography", in Saferstein, Richard, Ph.D., editor. *Forensic Science Handbook, Volume II*. Englewood Cliffs, N. J.: Prentice Hall, 1988, pp. 38-67.
- 14.3.5 Hyver, K.J., Sandra, P., editor. *High Resolution Gas Chromatography, Third Edition*. Hewlett Packard Company, 1989.
- 14.3.6 Rood, Dean, *A Practical Guide to the Care, Maintenance, and Troubleshooting of Capillary Gas Chromatographic Systems, 3rd ed.*, Wiley-VCH, New York, 1999.
- 14.3.7 Regis Chemical Company. *A User's Guide to Chromatography*. Morton Grove, IL: Regis Chemical Company, 1976, pp. 20-114.
- 14.3.8 Hewlett Packard and Agilent Technologies GC instrument manuals.
- 14.3.9 Pierce, A. E., *Silylation of Organic Compounds*, Pierce Chemical Company, Rockford, IL 1968.
- 14.3.10 DFS Controlled Substances Procedures Manual, Estimation of Uncertainty of Measurement Section.

14.4 Assignments

- 14.4.1 Completion of required reading assignments (14.3.1, 14.3.3, 14.3.10), study questions and practical exercises

14.5 Study Questions

- 14.5.1 What is gas chromatography?
- 14.5.2 What types of information are obtained from GC?

14.5.3 Draw a schematic diagram for a GC and describe the purpose of each component.

14.5.4 Define the following terms:

- Carrier gas
- Mobile phase
- Stationary phase
- Partition
- Volatility
- Distribution coefficient
- Retention index
- Linear velocity
- Flow rate
- Derivatization
- Internal standard

14.5.5 Describe the solid support used in a capillary column GC system.

14.5.6 What general criteria should all stationary phases possess?

14.5.7 What general criteria should all mobile phases possess?

14.5.8 Besides the stationary phase, what factors influence column selection for a given GC application?

14.5.9 What determines the appropriate column diameter for a given GC system? The appropriate length?

14.5.10 Describe how the following concepts affect GC separation between components:

- Solubility
- Boiling point
- Intermolecular forces

14.5.11 Diagram and describe the cross-section of a capillary column.

14.5.12 What factors influence the “inertness” of a column?

14.5.13 What is the purpose of the polyimide/polyamide coating on a fused silica column?

14.5.14 What advantages does a bonded/cross-linked phase column possess?

14.5.15 What is column bleed?

14.5.16 When and why are columns conditioned? Describe the process.

14.5.17 What factors govern the operating temperature of a given GC column? What are the upper and lower temperature limits for the following liquid phases? What is the effect of operating above or below these limits?

- HP-1 (for capillary columns)
- HP-5 MS (for capillary columns)
- DB-35

14.5.18 Define:

- retention time (T_R or t_R)
- relative retention time (RRT)

- retention volume
- unretained retention time (t_m)
- corrected or adjusted retention time (t'_R or t''_R)
- phase ratio
- selectivity

14.5.19 Define partition coefficient (K)? What is it a function of? How does it relate to equilibrium? What is meant if $K = 1$?

14.5.20 What is the partition ratio/capacity ratio (k)? How does it relate to retention time?

14.5.21 Define the following:

- theoretical plate (n)
- theoretical plate height /height equivalent to a theoretical plate (H or HETP)
- average linear gas velocity

14.5.21.1 How is the # of N related to column efficiency?

14.5.22 Define Resolution (R).

14.5.22.1 What is chromatographic resolution a function of?

14.5.22.2 Why is resolution not the best measure of column efficiency and column performance?

14.5.23 Diagram and explain the Van Deemter plot. Why is Helium a good choice for a carrier gas?

14.5.24 What effect do the following have on retention time:

- Concentration
- Other compounds in the sample
- Free base/acid form vs. salt form

14.5.25 What should be the minimum retention time of the first eluting component in a sample of one or more components to ensure the sample has spent enough time in the liquid phase to achieve reasonable separation?

14.5.26 Discuss the sample introduction of gases, vapors, and volatile liquids into a GC.

14.5.27 What is meant by flash vaporization?

14.5.28 Describe the proper manual injection technique.

14.5.29 What factors govern the amount of sample to be injected? How much sample/component can the average capillary column hold? What factors influence this?

14.5.30 Describe the purpose and functionality of a Merlin Microseal.

14.5.31 What are the differences and purposes of “split” injection, “splitless” injection and “on-column” injection?

14.5.31.1 Draw a diagram of the injection port and illustrate the carrier gas flow throughout for both split and splitless injections.

14.5.32 What is an injection port liner? What is it made of? Why is it used? Describe the packing process including the materials used. How are they deactivated prior to use?

- 14.5.33 What is a “split ratio” and how is it calculated?
- 14.5.33.1 What factors govern the use of a particular split ratio (100:1 vs. 50:1)?
- 14.5.34 What is gas saver and how is it used?
- 14.5.35 What is EPC? Explain the difference between constant flow and constant pressure.
- 14.5.36 Describe the “solvent effect”?
- 14.5.36.1 How is it done and why is it important?
- 14.5.36.2 What factors affect the efficiency of the solvent effect?
- 14.5.37 What is meant by “cold trapping” and how is it done?
- 14.5.38 Why is it necessary to regulate the carrier gas flow?
- 14.5.38.1 How is this done?
- 14.5.38.2 What factors influence the optimum flow rate for a given carrier gas?
- 14.5.38.3 If the carrier gas is too fast or too slow how will it affect the peak shapes of your sample components?
- 14.5.38.4 How will it affect the detector?
- 14.5.39 Discuss what a Purged Ultimate Union (P.U.U.) is and how it is beneficial.
- 14.5.40 Discuss the Flame Ionization Detector (FID) with respect to the following:
- How does it work?
 - Carrier gas requirements
 - Sensitivity
 - Temperature requirements
 - Insensitivities
 - Advantages/disadvantages with respect to organic drug analysis
- 14.5.41 What is “make-up” gas?
- 14.5.41.1 How and why is it used?
- 14.5.41.2 What determines which gas will be used as a make-up gas?
- 14.5.42 Explain the following statement: “response is proportional to the number of carbon atoms in the sample”.
- 14.5.42.1 What type(s) of detector is this statement applicable to?
- 14.5.42.2 What is meant by “mass-flow” detector?
- 14.5.43 What types of compounds should be included in a test mixture used to assess chromatographic performance? Why would these compounds be included and what would each be designed to evaluate?
- 14.5.44 What types of GC’s (model, manufacturer, etc.) does the drug laboratory use?
- 14.5.44.1 What types of injection ports, carrier gases, flows, columns and detectors does each GC incorporate?

14.5.45 Outline a logical troubleshooting schematic for isolating the source of a GC system problem.

14.5.46 Describe how to change the septum/Microseal on the GC.

14.5.46.1 What are some of the problems encountered when a septum is too tight or too loose?

14.5.47 What are some of the common causes and remedies for the following GC system problems:

- No peaks
- Solvent peak only
- Baseline drift or unstable baseline
- Ghost peaks
- Tailing peaks
- Leading peaks
- Split peaks
- Baseline rise before or after a peak
- Baseline drop after a peak
- Retention time shift

14.5.48 Describe the preventative maintenance schedule and QA/QC procedures performed on the GC's.

14.5.49 Discuss the operation of an autosampler.

14.5.50 What is "needle discrimination" and how is it corrected?

14.5.51 Explain how derivatization is performed, including why it is used sometimes for analysis. Name some common derivatizing agents used by DFS.

14.5.52 Describe the internal standard method of quantitation. When using a one point calibration, describe the function and acceptance criteria of the "check standard".

14.5.53 What is the mathematical formula for calculating purity? Define each variable.

14.5.53.1 If an amphetamine sulfate solution has a concentration of 2.4 mg/mL, what is the concentration of the base form of amphetamine in this solution?

14.5.54 If two drug compounds were to co-elute on the GC, what could be done to resolve the peaks?

14.5.55 Explain as to a jury how a GC operates.

14.6 Practical Exercises

14.6.1 Write a method for the GC which creates a program which will perform the following:

- Inlet and detector temperatures: 280°C
- Oven temperature: 150-250°C, 10°C per minute, initial hold of 2 minutes
- Total run time: 20 minutes
- Split ratio: 50:1
- Column flow rate: 1 mL/min

14.6.1.1 Now inject a mixture of cocaine and propoxyphene and see if the two compounds resolve. If not, change the method one parameter at a time until they are resolved (This can also be accomplished through discussion with your primary GC operator).

14.6.2 Inject the following standards on the GC and describe their peak shapes:

- Methamphetamine HCl in MeOH
- Methamphetamine base in MeOH
- Flash-derivatized Methamphetamine HCl in CHCl_3 as described in the Controlled Substances Procedures Manual.

14.6.3 Complete pipette training module in Qualtrax.

14.6.4 Obtain samples of Methamphetamine and Hash Oil from the TC and perform a quantitative analysis using the appropriate method in the Procedures Manual.

14.6.4.1 Fill out an appropriate Uncertainty Budget and discuss the estimation of the uncertainty of measurement as it relates to each procedure.

14.7 Modes of Evaluation

14.7.1 Written examination

14.7.2 Court exercise (mini-mock trials)

14.7.3 Technical/Oral session(s)

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15 MASS SPECTROMETRY**15.1 Objectives**

- 15.1.1 To familiarize the trainee with the theory and application of mass spectrometry (MS) in drug analysis
- 15.1.2 To familiarize the trainee with the MS instrumentation and software used in the laboratory

15.2 Modes of Instruction

- 15.2.1 Self-directed study through reading assignments
- 15.2.2 Presentations, demonstrations and study questions
- 15.2.3 Practical exercises

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 - 15.3.2 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 5-61 through 5-72.
 - 15.3.3 Virginia Department of Forensic Science Controlled Substances Procedures Manual, Mass Spectrometry Section.
 - 15.3.4 Allen, A. C. et al. "The Cocaine Diastereomers", *Journal of Forensic Sciences*, Vo., 26, No. 1, 1981.
 - 15.3.5 Yinon, Jehuda. *Forensic Mass Spectrometry*. Boca Raton: CRC Press, Inc., 1987.
 - 15.3.6 McLafferty, Fred W. and Venkataraghavan, Rengachari. *Mass Spectral Correlations, Second Edition*. Washington, D. C.: American Chemical Society, 1982.
 - 15.3.7 McLafferty, F. W. *Interpretation of Mass Spectra, Second Edition*. Reading, MA: W. A. Benjamin, Inc., 1973.
 - 15.3.8 Message, Gordon M. *Practical Aspects of Gas Chromatography/Mass Spectrometry*. New York: John Wiley & Sons, 1984.
 - 15.3.9 Mills, Terry, III and Roberson, J. Conrad. *Instrumental Data for Drug Analysis, Second Edition*. New York: Elsevier, 1987.
 - 15.3.10 Mills, Terry, III and Roberson, J. Conrad. *Instrumental Data for Drug Analysis, Third Edition*. New York: CRC Press, 2006.
 - 15.3.11 Rösner, Peter, et al. *Mass Spectra of Designer Drugs*. Germany: Wiley-VCH, 2007.
 - 15.3.12 Computer-based NIST library of organic compounds (NIST98.1 or higher)
 - 15.3.13 Agilent Technologies GC/MS instrument manuals
 - 15.3.14 Agilent Technologies computer-based tutorials
 - 15.3.15 Silverstein, R. M. et al. *Spectrometric Identification of Organic Compounds* New York: John Wiley & Sons, 1991, pp. 3-41.

- 15.3.16 Watson, J. T. *Introduction to Mass Spectrometry*, 3rd ed., New York: Lippincott, 1997.
- 15.3.17 Steiner, R. "Mass Spectrometry Lecture", Virginia Department of Forensic Science, April 2000.
- 15.3.18 Beynon, J. et al. *The Mass Spectra of Organic Molecules*, Amsterdam: Elsevier Publishing Co., 1968. pp. 14-29.
- 15.3.19 Smith, R.M., The Mass Spectrum of Cocaine, *J. Forensic Sciences*, 1997, 42(3): 475-480.
- 15.3.20 Smith, R.M., *Understanding Mass Spectra: A Basic Approach*, 2nd ed., New Jersey: Wiley Interscience, 2004.

15.4 Assignments

- 15.4.1 Completion of required reading assignments (15.3.1, 15.3.3, 15.3.4, 15.3.15, 15.3.18, 15.3.19)
- 15.4.2 Completion of study questions and practical exercises

15.5 Study Questions

- 15.5.1 What is mass spectrometry? Describe the theory behind its use as an identification technique.
- 15.5.2 Draw a schematic diagram of a GC/MS. What is the purpose of each component?
- 15.5.3 Define the following terms:
- Relative abundance
 - Base peak
 - Molecular ion
 - Precursor ion
 - Product ion
 - Mass/charge ratio
 - Mass spectrum
 - Unit mass resolution
 - Normalization
 - Carbonium ion
 - Cleavage
 - Dalton
 - Isobaric
 - Radical
 - Doubly charged ion
 - Calibration compound
 - Torr
 - Atmosphere
 - Total Ion Current
- 15.5.4 What is the sensitivity of a GC/MS compared to color tests and TLC?
- 15.5.4.1 How do the various models of GC/MS systems in your lab compare with respect to sensitivity?
- 15.5.4.2 What factors determine this?
- 15.5.5 Why can column bleed cause a problem in GC/MS and how is it corrected? Septum bleed?
- 15.5.6 How can non-volatile compounds be introduced into a mass spectrometer?

- 15.5.7 Explain and diagram the capillary direct method of sample transfer for the Agilent systems in the laboratory. What things must an interface between GC and MS accomplish?
- 15.5.8 What is the most common mode of ionization in forensic drug chemistry?
- 15.5.9 Diagram and describe the components of the E.I. source for the Agilent systems in your lab.
- Are the ions formed positive or negative?
 - Do they have an even or odd number of electrons?
 - What is the ionization efficiency of this technique?
 - What governs the relative abundance of the ions formed?
- 15.5.10 What governs the number and energy of the electrons emitted by the filaments?
- 15.5.11 From what are the filaments made?
- 15.5.12 What is an “ionization appearance potential” curve?
- 15.5.12.1 What is the usual electron energy used in an E.I. source for ionization and why?
- 15.5.12.2 What effect does variation in this energy have on ion abundance?
- 15.5.13 What vacuum conditions are necessary in the ionization source and the analyzing regions of a MS and why?
- 15.5.13.1 Describe how a rough pump works.
- 15.5.13.2 Describe how a diffusion pump works.
- 15.5.13.3 Describe how a turbomolecular pump works.
- 15.5.13.4 Is it necessary that the vacuum remain constant?
- 15.5.14 What temperature conditions must be maintained in the ion source? Why is temperature important?
- 15.5.15 Explain how chemical ionization is performed.
- 15.5.15.1 What are its advantages/disadvantages with respect to electron ionization?
- 15.5.15.2 Do the ions formed by this process have an even or odd number of electrons?
- 15.5.16 Describe how a quadrupole mass analyzer works.
- 15.5.16.1 What factors influence the practical limits of the quadrupole as a mass filter?
- 15.5.16.2 What determines whether an ion will have a stable trajectory through the quadrupoles?
- 15.5.16.3 Draw a graphical representation of ion stability for ramping DC and RF voltages in a quadrupole filter.
- 15.5.17 Define mass resolution.
- 15.5.17.1 What does a resolution of 500 mean?
- 15.5.17.2 What is the resolution a function of?
- 15.5.18 Describe how an electron multiplier works.

- 15.5.18.1 Why is it referred to as a continuous dynode?
- 15.5.18.2 With what is the inner surface of the electron multiplier coated?
- 15.5.18.3 What is a “high energy dynode” and how does it work? Describe a triple axis detector.
- 15.5.19 Why is the electron multiplier the detector of choice?
- 15.5.20 Explain how the PBM library search routine works.
- How does the software decide which peaks to use?
 - What makes a peak significant to each of these searches?
 - What are the limitations of the computer library?
- 15.5.21 What reference spectra collections are available for your use?
- Do they consist of “normalized” data?
 - Do they contain verified data?
 - If not, are they still viable references for spectral comparisons?
- 15.5.22 Can enantiomers and diastereomers be differentiated via MS?
- Can ephedrine and pseudoephedrine be distinguished by MS?
 - Obtain literature mass spectra of the cocaine diastereomers and discuss the differences
- 15.5.23 What requirements are necessary for an ion to be considered a molecular ion?
- 15.5.23.1 Define the term “logical neutral loss” and give examples.
- 15.5.23.2 What mass losses during fragmentation are highly unlikely?
- 15.5.24 List the isotopic abundances for each of the following elements: H, C, N, O, F, Si, P, S, Cl, Br, I
- 15.5.25 What percentage of intensity of a molecular ion is contributed to the M+1 peak by carbon atoms?
- 15.5.25.1 What is the formula for calculating the number of carbon atoms in a molecule?
- 15.5.25.2 How can the M+1 peak be used to determine the molecular weight?
- 15.5.26 What is the nitrogen rule?
- 15.5.27 If a molecular formula has been determined, how can the number of rings and double bonds be determined?
- 15.5.28 Describe how fragmentation patterns are influenced by:
- Branched carbon atoms
 - Double bonds
 - Rings
 - Hetero-atoms
 - Carbonyl groups
- 15.5.29 What are the M+2 (or A+2) elements?
- 15.5.30 In what types of compounds is a molecular ion peak frequently not detectable?

- 15.5.31 In what types of compounds are molecular ion peaks most likely to occur?
- 15.5.32 What is the most desirable characteristic of mass spectra of trimethylsilyl derivatives?
- 15.5.33 What do the peaks occurring at higher mass numbers than the molecular ion often represent?
- 15.5.34 What ions can be associated with the following m/e ratios?
- 43
 - 58
 - 77
 - 91
- 15.5.35 Describe the term “rearrangement”.
- 15.5.35.1 Describe a “gamma hydrogen (McLafferty) rearrangement” and show examples.
- 15.5.35.2 Describe an “adjacent hydrogen rearrangement” and show examples.
- 15.5.36 Define the following terms and describe how these terms relate mass spectrometry to chromatography?
- scan rate
 - scan cycle time
 - reset time
 - a/d conversion rate
 - spectral tilting
 - Mass peak detect threshold
 - GC peak detect threshold
- 15.5.37 Explain the terms “sequence file”, “sequence log”, “macro” and “data file”.
- 15.5.38 Draw the structure of PFTBA and relate the structure to the ions found in the autotune report.
- 15.5.39 Explain sequencing and what its utility is. Give a few examples of macros that are used in your laboratory.
- 15.5.40 Set up a sequence table on a Chemstation. Print out the result in “brief” format and describe what each field represents.
- 15.5.41 Describe the autotuning procedure, explaining what each part of the program accomplishes.
- 15.5.42 Describe how to perform the following techniques:
- Headspace analysis
 - Wet needle injection
- 15.5.43 What is SIM and what is it used for?
- 15.5.44 Describe the preventative maintenance schedule and the QA/QC procedures performed on the GC/MS.
- 15.5.45 Why is DFTPP used in the DFS Controlled Substance QA mix?
- 15.5.46 Describe the use of barcoding and how it relates to sample tracking.
- 15.5.47 Describe the conditions needed for using retention time data from GC/MS runs.

- 15.5.48 Describe the use of blanks on the GC/MS.
- 15.5.49 Describe the various techniques of “Atmospheric Pressure Ionization” including:
- 15.5.49.1 Electrospray (ES)
 - 15.5.49.2 Atmospheric pressure chemical ionization (APCI).
- 15.5.50 Explain as to a jury how a mass spectrometer operates.

15.6 Practical Exercises

- 15.6.1 Perform an autotune on the GC/MS and describe what each value on the report represents. What types of parameter values may indicate a problem with the instrument?
- 15.6.2 Compare the mass spectral data for ephedrine, pseudoephedrine and methamphetamine. What are the significant differences which make these spectra unique to their parent compound?
- 15.6.3 Run LSD and LAMPA on a GC/MS system in your lab. Compare the mass spectra and indicate their differences.
- 15.6.4 Obtain an unknown spectrum from the TC. Using interpretive methods, give as much information about the unknown compound as possible.
- 15.6.5 Create two methods using the parameters listed below. Run a cocaine standard on each method and compare the results.
- 15.6.5.1 Method 1
 - Oven temperature: 220 – 240 °C @ 20 °C / minute
 - Scan Range: 400 – 14 amu
 - a/d = 4
 - 15.6.5.2 Method 2
 - Oven temperature: 220 – 240 °C @ 20 °C / minute
 - Scan Range: 400 – 14 amu
 - a/d = 0
- 15.6.6 Change the background method so that the mass detect threshold is set to zero. Run the background and discuss the different possibilities for setting the thresholds in methods for drug analysis.
- 15.6.7 Obtain a sample of GHB from the TC or designee. Create the silyl derivative and analyze via GC/MS using the GHB procedure in the Controlled Substances Procedures Manual.
- 15.6.8 Run a sample of diluted (1:10) cocaine standard in splitless and pulsed splitless modes, full scan. Discuss any differences in chromatography and spectra.
- 15.6.9 Perform a headspace injection of a mixture of volatile solvents.
- 15.6.10 Using spectral interpretation techniques, including the NIST MS Interpreter program, account for the major peaks found in the following spectra: Cocaine, Heroin, Methamphetamine, a current Cannabimimetic Agent and a current Research Chemical/Designer Drug.

15.7 DART-TOF Training

15.7.1 Required readings (all found in Training Manual References folder on DFS intranet)

- 15.7.1.1 Cody R.B. et al. Direct Analysis in Real Time (DART) Mass Spectrometry. *JEOL News* 2005; 40(1), pp. 8-12.
- 15.7.1.2 Tamura, J. and Osuga, J. *New Generation LC-TOF/MS* “AccuTOF”.
- 15.7.1.3 Steiner, Larson, “Validation of the Direct Analysis in Real Time Source for Forensic Drug Screening”, *J. For. Sci.*, May 2009, 54(3), 617-622.
- 15.7.1.4 Bennett, Steiner, “Detection of gamma-hydroxybutyric acid in various drink matrices via AccuTOF-DART”, *J. Forensic Sciences*, March 2009, 54(2), 370-75.
- 15.7.1.5 Easter, Steiner, “Pharmaceutical Identifier Confirmation via AccuTOF-DART”, *Forensic Science International*, 240(2014); 9-20.
- 15.7.1.6 Gross, J., “Direct analysis in real time – a critical review on DART-MS”, *Analytical Bioanalytical Chemistry*, published online 15 September 2013.
- 15.7.1.7 Lesiak, A. et al, “Direct analysis in real time mass spectrometry (DART-MS) of “bath salt” cathinone drug mixtures”, *Analyst*, 2013, 138, 3424-3432.
- 15.7.1.8 Lesiak, A., Shepard, J., “Recent advances in forensic drug analysis by DART-MS”, *Bioanalysis*, 2014 6(6), 819-842.

15.7.2 DART-TOF Questions

- 15.7.2.1 Diagram and describe the following components of the AccuTOF-DART system:
- DART source
 - Vacuum system
 - Ion optics region
 - Flight tube
- 15.7.2.2 Describe the positive and negative ionization processes of the DART source.
- 15.7.2.3 Discuss the principles of time-of-flight mass spectrometry, including how mass separation occurs. What is the resolution of the AccuTOF-DART system in your laboratory?
- 15.7.2.4 Describe, including advantages and disadvantages, the various ways to introduce a sample into the DART source.
- 15.7.2.5 Discuss how the AccuTOF-DART system is calibrated.
- 15.7.2.6 Discuss the spectral output of the AccuTOF-DART system and how it can be used to determine the elemental composition of an unknown.
- 15.7.2.7 Discuss the differentiation of empirical formula isomers.
- 15.7.2.8 Discuss the use of the Mass Mountaineer program in the interpretation of data from the AccuTOF-DART.
- 15.7.2.9 Discuss the advantages/disadvantages of there being no chromatography prior to the AccuTOF-DART analysis.

15.7.2.10 Describe the preventative maintenance schedule and the QA/QC procedures performed on the DART-TOF system.

15.7.3 Practical Exercises/Instrument Certification

Training Samples – The TC will provide a minimum of ten (10) training samples, which should include a minimum of three (3) “pharmaceutical identifier confirmation” samples. In conjunction with the Primary Operator, the trainee will obtain DART-TOF data on each sample, with the Primary Operator providing gradually less oversight as the trainee progresses. In order to provide the most educational experience, the ten (10) samples SHALL NOT be run in one day and should be spaced out over the course of several weeks. This will allow the trainee to utilize the system several different times to fully obtain the skills necessary to acquire and interpret the data. Training sample #10 should be run entirely without assistance from the Primary Operator and will be used as final certification that the trainee can fully utilize the instrument for casework, independently. Dates of completion of required readings and training samples will be kept by the TC to ensure completion of the entire set of training samples.

15.8 Modes of Evaluation

15.8.1 Written examination

15.8.2 Court exercise (mini-mock trials)

15.8.3 Technical/Oral session(s)

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16 HIGH PERFORMANCE LIQUID CHROMATOGRAPHY**16.1 Objectives**

- 16.1.1 To familiarize the trainee with the theory and application of high performance liquid chromatography (HPLC) in Controlled Substances analyses.
- 16.1.2 To familiarize the trainee with the HPLC instrumentation and software.

16.2 Modes of Instruction

- 16.2.1 Self-directed study through reading assignments
- 16.2.2 Presentations and demonstrations
- 16.2.3 Study questions
- 16.2.4 Practical exercises

16.3 References

- 16.3.1 M Moffat, A.C., editor. *Clarke's Analysis of Drugs and Poisons*, 3rd edition. London: The Pharmaceutical Press, 2004 pp 500-534.
- 16.3.2 Smith, R. N., Ph.D. "Forensic Applications of High-Performance Liquid Chromatography", in Saferstein, Richard, Ph.D., editor. *Forensic Science Handbook*. Englewood Cliffs, N. J.: Prentice Hall, 1982, pp. 28-91.

16.4 Assignments

- 16.4.1 Completion of reading assignments
- 16.4.2 Study questions and practical exercises

16.5 Study Questions

- 16.5.1 Describe HPLC.
- 16.5.2 Draw a schematic diagram of a HPLC system and describe the function of each component.
- 16.5.3 What types of drugs are better suited for HPLC analysis, versus analysis by gas chromatography? Give examples.
- 16.5.4 Define the following:
- Mobile phase
 - Capacity factor
 - Isocratic elution
 - Gradient elution
 - Normal phase HPLC
 - Reverse phase HPLC
- 16.5.5 Describe the photodiode array detector. What are the advantages of diode array detection? What other detectors are available for HPLC systems?
- 16.5.6 How discriminating are UV spectra?

- 16.5.7 Describe the use of buffers giving examples and their use for specific separations.
- 16.5.8 Describe how you might choose an HPLC column for analysis?
- 16.5.9 Describe the effect of particle size, flow rate, and column dimensions regarding separation with HPLC columns.

16.6 Practical Exercises

- 16.6.1 Prepare assigned samples and standards to be analyzed on the HPLC. Identify each analyte by retention time and UV spectral library matching.
- 16.6.2 Perform a quantitative cannabinoid analysis of five (5) known samples. The batch should include instrument preparation (buffers, backflush, prime etc.), calibrators, controls and samples. Identify each cannabinoid by retention time and UV spectral library matching.

16.7 Modes of Evaluation

- 16.7.1 Written examination
- 16.7.2 Court exercise (mini-mock trial) (as needed)
- 16.7.3 Technical/Oral session(s) (as needed)

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17 INFRARED SPECTROPHOTOMETRY**17.1 Objectives**

- 17.1.1 To familiarize the trainee with the theory and application of infrared spectrophotometry in drug analysis
- 17.1.2 To familiarize the trainee with the FTIR and Discov-IR instrumentation and software used in the laboratory

17.2 Modes of Instruction

- 17.2.1 Self-directed study through reading assignments and study questions
- 17.2.2 Presentations and demonstrations
- 17.2.3 Practical exercises

17.3 References

- 17.3.1 Moffat, A. C., *et al.*, editors. *Clarke's Analysis of Drugs and Poisons*. London: The Pharmaceutical Press, 2004, pp. 328-345.
- 17.3.2 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 5-17 through 5-29.
- 17.3.3 DFS Controlled Substances Procedures Manual, FTIR Section.
- 17.3.4 Suzuki, Edward M., Ph.D. "Forensic Applications of Infrared Spectroscopy", in Saferstein, Richard, Ph.D., editor. *Forensic Science Handbook, Volume III*. Englewood Cliffs, N. J.: Regents/Prentice Hall, 1993, pp. 71-195.
- 17.3.5 Cooper, James. *Spectroscopic Techniques for Organic Chemists*. New York: John Wiley & Sons, 1980, pp. 1-52.
- 17.3.6 Smith, A. Lee. *Applied Infrared Spectroscopy*. New York: John Wiley & Sons, 1979.
- 17.3.7 Mills, Terry, III and Roberson, J. Conrad. *Instrumental Data for Drug Analysis, Second Edition*. New York: Elsevier, 1987.
- 17.3.8 Mills, Terry, III and Roberson, J. Conrad. *Instrumental Data for Drug Analysis, Third Edition*. New York: CRC Press, 2006.
- 17.3.9 Computer-based Georgia Bureau of Investigation (Mills) library of drug compounds.
- 17.3.10 Silverstein, R. M. et al. *Spectrometric Identification of Organic Compounds*. New York: John Wiley & Sons, 1991.
- 17.3.11 Thermo Nicolet Instrument Manuals.
- 17.3.12 Discov-IR Instrument Manual.

17.4 Assignments

- 17.4.1 Completion of required reading assignments (17.3.1, 17.3.3)
- 17.4.2 Study questions

17.4.3 Practical exercises

17.5 Study Questions

17.5.1 What is infrared spectrophotometry? Describe the theory behind its use as an identification technique including types of information obtained and specificity.

Draw a schematic diagram for a FTIR/ATR.

17.5.2 Describe the electromagnetic spectrum.

17.5.2.1 What is the upper and lower limit on the infrared region of the electromagnetic spectrum?

17.5.2.2 What region is the most useful analytically?

17.5.2.3 What is the standard range of most instruments?

17.5.3 Define the following terms:

- Wave
- Wavelength
- Wavenumber
- Frequency
- Dipole moment
- Absorption
- Transmittance
- Overtone
- Harmonic vibration
- Combination band
- Fundamental vibration
- Monochromator
- Interferometer
- Homonuclear
- Amplitude
- Centerburst

17.5.4 Draw a block diagram of the FTIR and describe the function of the major components.

17.5.4.1 Describe the different types of radiation sources for FTIR instruments.

17.5.4.2 Describe the different types of detectors available for FTIR instruments.

17.5.4.3 Sketch a Michaelson interferometer and describe how it works.

17.5.5 What is “Fourier Transform” and how does it apply to IR?

17.5.6 Explain the theory behind the Attenuated Total Reflectance (ATR) sampling unit including the differences between single-bounce and multi-bounce units.

17.5.6.1 Describe any differences in the spectra obtained using ATR vs. regular transmittance.

17.5.6.2 Explain the function of the ATR correction within the software including when it is permissible to use a corrected spectra in case work.

17.5.7 What is meant by the “fingerprint region” of an IR spectrum? Why is it significant?

- 17.5.8 Can IR differentiate optical isomers? Diastereomers? Structural isomers?
- 17.5.9 Why is polystyrene used to check the function of the FTIR?
- 17.5.10 Which organic functional groups correspond to the following absorption frequencies?
- 3639-3633 cm^{-1}
 - 2990-2850 cm^{-1}
 - 1650-1510 cm^{-1}
 - 1750-1740 cm^{-1}
 - 770-690 cm^{-1}
 - 760-540 cm^{-1}
- 17.5.11 Why is KBr used in the preparation of solid samples?
- 17.5.12 What two conditions must be met in order for infrared absorption to occur?
- 17.5.13 What is the intensity of an IR absorption proportional to?
- 17.5.14 Explain Beer's Law.
- 17.5.15 What are the two basic categories of molecular vibration?
- 17.5.16 What are the four types of bending?
- 17.5.17 What is meant by vibrational coupling?
- 17.5.18 Describe the differences between dispersive and non-dispersive instruments.
- 17.5.19 What are the advantages of FTIR over dispersive IR?
- 17.5.20 Which will vibrate with higher frequency, C-H bond or a C-C bond and why?
- 17.5.21 What does hydrogen bonding do to the vibrational frequency of a hydroxyl or an amine group?
- 17.5.22 Describe the absorptions for the following groups:
- -O-H
 - -N-H
 - $>\text{C}=\text{O}$
 - -C-O-
 - -C-H
 - $-\text{C}\equiv\text{N}$
 - $-\text{NO}_2$
 - Aromatic Substitutions
- 17.5.23 What is polymorphism and how does it influence IR spectra?
- 17.5.24 Describe how to prepare the following:
- KBr pellet
 - Sandwiched thin film
 - Film deposited on KBr
- 17.5.25 How does over or under-grinding KBr/sample mixtures influence the IR spectra?

- 17.5.26 What model IR does your laboratory use?
- 17.5.26.1 What radiation sources and detectors are used in the FTIR and its attachments in your laboratory?
- 17.5.27 What problems are encountered in using IR as a quantitative technique?
- 17.5.28 What causes a sloped baseline?
- 17.5.29 Explain baseline correction and how it is performed.
- 17.5.30 What is spectral subtraction and under what conditions is it possible?
- 17.5.31 What are the differences between background subtraction and spectral subtraction?
- 17.5.32 What is the relationship between resolution and data point spacing?
- 17.5.33 What resolution are samples normally run in your laboratory?
- 17.5.34 Can a library match be used to identify a sample? Why or why not?
- 17.5.35 Describe how a spectrum is auto-saved and/or saved.
- 17.5.36 Describe how ATR analysis can be run on powders, liquids and mixtures.
- 17.5.37 What are the advantages/disadvantages of a GC/MS compared to an IR when used for identification purposes?
- 17.5.38 Describe the preventative maintenance schedule and the QA/QC procedures performed on the IR including the VAL-Q/VAL-PRO software.
- 17.5.39 Describe as to a jury how an FTIR operates.
- 17.5.40 Draw a block diagram of the Discov-IR instrument and describe the function of the major components.
- 17.5.41 Explain the sample deposition process that is unique to the Discov-IR. What are the benefits?
- 17.5.42 What type of spectra are obtained from the Discov-IR? How will these spectra differ from those collected with ATR?
- 17.5.43 Discuss the differences between solid phase spectra and gas phase spectra.
- 17.5.44 Explain the operational relationship between the Discov-IR and the GC.
- 17.5.45 Describe how to set up a sequence including a standard, blank and sample.
- 17.5.46 What is the importance of depositing the sample over the same area as the blank?
- 17.5.47 Which instrument should be started first? Why?
- 17.5.48 During a Discov-IR run, where is the background used for subtraction collected?
- 17.5.49 How does this differ when using the “First BL” and the “Add BL” functions?
- 17.5.50 When would you use the “First BL” and “Add BL” functions?
- 17.5.51 Explain how to perform a post-run rescan of a sample. When would the use of this feature be important?

17.5.52 Describe the preventative maintenance schedule and the QA/QC procedure performed on the Discov-IR.

17.6 Practical Exercises

- 17.6.1 Using the standards in the laboratory, prepare the following samples, analyze via FTIR, and discuss the differences in the spectra:
- Methamphetamine HCl, Phentermine HCl, Ephedrine HCl (ATR)
 - Cocaine base, Cocaine HCl (ATR)
 - MDA, MDMA, MDEA (ATR)
- 17.6.2 Obtain a mixture from the TC. Using spectral subtraction determine the two components present. Devise and carry out an extraction of the two components and verify with FTIR.
- 17.6.3 When available, run standards of methamphetamine and phentermine on the GC/FTIR.
- 17.6.4 Obtain samples from the TC including procaine HCl, cocaine base/procaine mixture, Amoxicillin and gamma-butyrolactone and run using the ATR.
- 17.6.5 Obtain a sample of Dronabinol from the TC. Analyze it via FTIR and GC/MS to meet the requirements of the Code of Virginia.
- 17.6.6 Obtain an unknown sample from the TC. Screen the sample via the normal analytical scheme and confirm using GC-Discov-IR.
- 17.6.7 Utilizing the report generator - create two sets of data for the standard, blank and sample.
- 17.6.8 Utilizing the GRAMS software – Perform a Spectral ID library search on the sample and perform peak integration and baseline correction on the standard and sample.

17.7 Modes of Evaluation

- 17.7.1 Written examination
- 17.7.2 Court exercise (mini-mock trials)
- 17.7.3 Technical/Oral session(s)

18 PHARMACEUTICAL PREPARATIONS**18.1 Objective**

18.1.1 To familiarize the trainee with the analytical procedures for pharmaceutical preparations

18.2 Modes of Instruction

18.2.1 Self-directed study through study questions and practical exercises

18.2.2 Presentations and demonstrations

18.3 References

18.3.1 *Physician's Desk Reference*. Montvale, N. J.: Medical Economics, various editions.

18.3.2 *Identadrug*, hardcopy series and website subscription

18.3.3 *Drug Identification Bible*. Grand Junction, CO: Amera-Chem, Inc., various editions including CD versions.

18.3.4 DEA Logo Index, various editions.

18.3.5 Epocrates, website subscription.

18.3.6 Pillbox – National Library of Medicine website.

18.3.7 Poison Control Center

18.3.8 *DEA Microgram Bulletin*, various editions.

18.3.9 Moffat, A. C., editor. *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986.

18.3.10 Clarke, E. G. C. *Isolation and Identification of Drugs, Volumes 1 and 2*. London: The Pharmaceutical Press, 1978.

18.3.11 Budavari, Susan, editor. *The Merck Index, Eleventh Edition*. Rahway, N. J.: Merck & Co., Inc., 1989.

18.3.12 DFS Controlled Substances Procedures Manual, Pharmaceutical Identifiers Section.

18.4 Assignments

Study questions and practical exercises

18.5 Study Questions

18.5.1 List the active ingredients of the following preparations:

- Oxycontin
- Adderall
- Demerol
- Preludin
- Ritalin
- Vyvanse
- Viagra

- Keflex
- Percodan
- Paxil
- Dalmane
- Librax
- Valium
- Fiorinal
- Wellbutrin
- Zoloft
- Vicodin
- Suboxone
- Xanax

- 18.5.2 List four possible references for tablet logo identification.
- 18.5.3 What information should be recorded in the case notes to ensure proper documentation of visual examination?
- 18.5.4 What are the analysis and reporting requirements for tablets and capsules in Schedules II – VI?
- 18.5.5 What steps should be taken if the results of an analysis are inconsistent with the manufacturer's specification with regard to content?
- 18.5.6 How does the analysis of an injectable dosage form differ if tampering is suspected?
- 18.5.7 What are the most accurate sources for determining the schedule of a drug?

18.6 Practical Exercises

- 18.6.1 Obtain 5-10 unknown preparations from the TC. Perform the visual examination with references from two sources. Include the schedule of each component.
- 18.6.2 Obtain a sample of an injectable dosage form from the TC. Following the procedure in the procedures manual, analyze the item for possible tampering. Determine the relative concentration of the drug present by using semi-quantitative TLC or UV.

18.7 Mode of Evaluation

- 18.7.1 Written examination

19 EXTRACTIONS**19.1 Objective**

19.1.1 To familiarize the trainee with the sample extraction methodology

19.2 Modes of Instruction

19.2.1 Self-directed study through reading assignments and study questions.

19.2.2 Practical exercises

19.3 References

19.3.1 Moffat, A. C., editor. *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986.

19.3.2 Clarke, E. G. C., *Isolation and Identification of Drugs*, London: The Pharmaceutical Press, 1972, Vol. 1, 2.

19.3.3 Higuchi, T. et al. "Ion Pair Extraction of Pharmaceutical Amines" *Analytical Chemistry*, Vol. 39, 1967, p. 974.

19.3.4 Watson, D. G. *Pharmaceutical Analysis* New York: Churchill Livingstone, 1999, pp. 17-47.

19.3.5 Virginia Department of Forensic Science Controlled Substances Procedures Manual, ¶¶ 6, 23, 24, 25 and 29.

19.4 Assignments

19.4.1 Completion of required reading assignments

19.4.2 Study questions and practical exercises

19.5 Study Questions

19.5.1 What is a matrix?

19.5.2 What is the difference between recrystallization and precipitation?

19.5.3 Define the following with respect to filtration:

- Supernatant
- Filtrate
- Porosity
- Retentivity
- Speed

19.5.4 Describe how a mixed solvent recrystallization is performed. How is a single solvent recrystallization performed?

19.5.5 Why is it necessary to have at least two test tubes in a centrifuge?

19.5.6 Define the following:

- Unsaturated solutions
- Saturated solutions

- Supersaturated solutions
- Reflux
- Azeotrope

- 19.5.7 What is the difference between evaporation and sublimation?
- 19.5.8 What problems may be encountered if ether evaporates to dryness?
- 19.5.9 What is a dry extraction?
- 19.5.10 What effect does temperature have on a drug extraction?
- 19.5.11 Describe how a series of smaller volume immiscible solvent extractions is more efficient than a single extraction using the same total volume of organic solvent, using the concept of 'partition coefficient' in your description.
- 19.5.12 How can water be removed from organic solvents?
- 19.5.13 What is an emulsion? How can they be prevented and what can be done when one occurs?
- 19.5.14 What does "salting out" mean?
- 19.5.15 What does pH stand for? pK_a ?
- 19.5.16 Describe how a pH controlled extraction works explaining equilibriums that are set up between two immiscible solvents.
- 19.5.17 Describe an extraction scheme that would recover most non-volatile compounds from an unknown.
- 19.5.18 What types of functional groups cause a compound to be acidic? Basic?
- 19.5.19 What does amphoteric mean?
- 19.5.20 Tell whether the drugs listed in Appendix A are acidic, basic, or neutral.
- 19.5.21 How is morphine best extracted from powder form?
- 19.5.22 How does hydrogen bonding come into play in liquid-liquid extractions?
- 19.5.23 What is ion-pairing? Diagram how it works using equilibrium considerations.
- 19.5.24 What types of factors should be considered in selecting solvents to use in extractions.
- 19.5.25 What separation advantages does chromatography have over extraction procedures? Disadvantages?
- 19.5.26 Describe how a soxhlet extractor works.
- 19.5.27 Describe the acetic acid extraction of psilocybin mushrooms emphasizing areas of concern.
- 19.5.28 What solvent should be used to extract salvinorin A from *Salvia divinorum* and why?
- 19.5.29 What is an extraction blank/procedural blank and when should it be used?
- 19.5.30 What extraction can be used to isolate water insoluble drugs from PEG solutions?

19.6 Practical Exercises

- 19.6.1 Obtain a Fiorinal with codeine capsule from the TC. Diagram a suitable extraction scheme using acid/base extractions. Perform these extractions to isolate each component into an organic solvent. Confirm each component utilizing either GC/MS or FTIR.
- 19.6.2 Obtain a sample of mushrooms from the TC. If none are available, use a standard of psilocybin. Perform the acetic acid extraction as outlined in the procedures manual. Confirm the presence of psilocyn.
- 19.6.3 Obtain a sample of a cocaine mixture from the TC or designee. Perform a dry extraction, and confirm using FTIR.
- 19.6.4 Obtain a sample of a food product containing THC. Perform the extraction outlined in the procedures manual. Confirm the presence of THC.
- 19.6.5 When available, perform the suggested Khat extraction on a sample of plant material. Confirm the presence of Cathinone and Cathine.

19.7 Mode of Evaluation

- 19.7.1 Written examination

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20 COURTROOM TESTIMONY**20.1 Objectives**

- 20.1.1 To familiarize the trainee with the functions of a courtroom criminal proceeding
- 20.1.2 To have the trainee prepare a current curriculum vitae and convey *voir dire* questioning during testimony
- 20.1.3 To familiarize the trainee with proper methods of presenting expert testimony during direct examination
- 20.1.4 To familiarize the trainee with the proper methods of defending analytical results during cross-examination

20.2 Modes of Instruction

- 20.2.1 Self-directed study through reading assignments and study questions
- 20.2.2 Observation of expert testimony
- 20.2.3 Practical exercises (mini-mock trials)

20.3 References

- 20.3.1 Kuzmack, Nicholas T., J.D., M.A. "Legal Aspects of Forensic Science", in Saferstein, Richard, Ph.D., editor. *Forensic Science Handbook*. Englewood Cliffs, N.J.: Prentice Hall, 1982, pp. 1-27.
- 20.3.2 Shellow, James M. "The Expert Witness in Narcotics Cases", in *Contemporary Drug Problems – A Law Quarterly*, Spring 1973, pp 81-104.
- 20.3.3 Travnikoff, Basil, Jr. and Kvick, Robert J. *How to Examine a Chemist in Drug Abuse Cases, First Edition*, 1971.
- 20.3.4 Bailey, F. L. and Rothblatt, H. B., *Handling Narcotic and Drug Cases*, Rochester, NY: The Lawyers Cooperative Publishing Co., 1972.
- 20.3.5 *Code of Virginia* (§ 19.2-187.1) and (§ 19.2-187).

20.4 Assignments

- 20.4.1 Completion of required reading assignments (20.3.1 – 20.3.3)
- 20.4.2 Completion of curriculum vitae
- 20.4.3 Study questions and mock trials

20.5 Study Questions

- 20.5.1 Discuss the role of the following during a trial:
 - Expert witness
 - Judge
 - Prosecutor
 - Defendant
 - Defense counsel
 - Jury

20.5.2 Define the following:

- *Voir dire*
- Direct examination
- Cross examination
- Redirect
- Chain of custody

20.5.3 Write a curriculum vitae (CV) in the format provided by the TC which includes educational background and work experience.

20.5.4 Describe a typical process from arrest to arraignment.

20.5.5 Describe a typical courtroom proceeding for a trial dealing with an individual accused of possession of a controlled substance, from the time the trial begins until final verdict by the jury. Be sure to include the order in which witnesses are called, arguments by trial counsel, and introduction of physical evidence.

20.5.6 How would you describe the characteristics of an effective expert witness? Likewise, what are some of the factors which make a poor expert witness?

20.5.7 Describe the ASCLD/LAB accreditation process and the benefits of being an accredited laboratory.

20.5.8 Discuss the importance the *Melendez-Diaz v. Massachusetts* decision played in forensic science testimony.

20.6 Practical Exercises

20.6.1 Conduct several mock trials in conjunction with the TC or designee which deal with the following aspects of testimony separately:

- *Voir dire*
- Chain of custody
- Drug analysis

20.6.2 Conduct several mock trials which will encompass all aspects of a potential trial setting. Be sure to include role players to serve as judges, attorneys, and jurors.

20.6.3 Observe examiners testify whenever possible.

20.6.4 Verbally answer the following possible direct examination questions to the TC or designee:

- What is your name?
- What is your occupation? For whom do you work?
- How long have you been so employed?
- What are your duties in this occupation?
- What education and training do you possess that qualifies you to perform your duties?
- What specific courses have you taken that are directly related to drug analysis?
- How are these courses related? For example, what did you learn in your general chemistry course that aids you in the analysis of drugs?
- Do you consider yourself an expert in the analysis of drugs?
- What is the definition of an expert witness?
- Is the university/college you graduated from accredited, and if so, by whom?
- Who conducted your training?
- What are his/ her/ their qualifications?
- What literature do you read relating to your job?
- How many analyses have you done on suspected drugs (or controlled substances)?

- Do you belong to a recognized society attesting to your qualifications as a drug chemist?
- Have you written any articles or published materials dealing with your work?

20.7 Mode of Evaluation

20.7.1 Passage of final mock trial

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21 SPECIAL TECHNIQUES AND ANALYSES**21.1 Objective**

- 21.1.1 To familiarize the trainee with the theory and application of additional instrumental techniques which are either used infrequently or not currently available at the DFS laboratory, such as UV and NMR.

21.2 Modes of Instruction

- 21.2.1 Self-directed study through reading assignments

21.3 References

- 21.3.1 Moffat, A. C., editor. *Clarke's Isolation and Identification of Drugs*. London: The Pharmaceutical Press, 1986, pp. 201-220; 221-236; and 264-275.
- 21.3.2 *Basic Training Program for Forensic Chemists*, U.S. Department of Justice, Drug Enforcement Administration, Office of Science and Technology, pp. 5-1 through 5-15; 5-49 through 5-59; 5-73 through 5-85.
- 21.3.3 Cooper, James. *Spectroscopic Techniques for Organic Chemists*. New York: John Wiley & Sons, 1980, pp. 53-135; 227-248.
- 21.3.4 Mills, Terry, III and Roberson, J. Conrad. *Instrumental Data for Drug Analysis, Second Edition*. New York: Elsevier, 1987.
- 21.3.5 Mills, Terry, III and Roberson, J. Conrad. *Instrumental Data for Drug Analysis, Third Edition*. New York: CRC Press, 2006.
- 21.3.6 Silverstein, R. M. et al. *Spectrometric Identification of Organic Compounds*. New York: John Wiley & Sons, 1991.

21.4 Assignments

- 21.4.1 Completion of reading assignments.

21.5 Study Questions**21.6 Mode of Evaluation**

- 21.6.1 Discuss reading assignments with TC

22 ADDITIONAL TRAINING**22.1 Review of Other Disciplines**

22.1.1 During the course of the Training Program the trainee should spend a small amount of time with the other disciplines (latent prints, forensic biology, etc.) located within the Department. This will allow the trainee to understand how evidence is maintained for multi-sectional analysis as well as understanding the general capabilities of the other sections. These visits will be coordinated by the TC.

22.2 DEA Forensic Chemist Seminar

22.2.1 Upon completion of training, the trainee shall attend the DEA Forensic Chemists Seminar contingent upon resources (funding, availability). Information of current schedules is found in *Microgram Bulletin* or by contacting the DEA Special Testing and Research Laboratory.

22.3 Technical/Administrative Review Training

22.3.1 The following documents shall be read and discussed with the TC or designee:

- Quality Manual - Section 17 Monitoring Results
- Technical Review Form
- ISO/IEC 17025:2005 – Section 4.13 Control of Records
- ASCLD/LAB-*International* Supplemental Requirements for the Accreditation of Forensic Science Testing Laboratories (2011) - Section 4.13 Control of Records

22.3.2 Practical Exercises

22.3.2.1 The trainee should document the review of at least twenty case files using the appropriate Technical Review Form. Case files should be generated by multiple examiners, if possible. The potential findings of the reviews shall be discussed with the TC. Technical Review forms generated in this capacity shall be marked as Training and retained in their Training File. The case files shall be technically reviewed by an authorized examiner pursuant to QM 17 prior to release.

23 CLANDESTINE LABORATORIES**23.1 Objectives**

- 23.1.1 To familiarize the trainee with syntheses routinely used in clandestine laboratories.
- 23.1.2 The completion of this section is not required in order for the trainee to become a qualified examiner.

23.2 Modes of Instruction

- 23.2.1 Study questions and practical exercises

23.3 References

- 23.3.1 DFS Controlled Substances Procedures Manual, Clandestine Laboratories Section.
- 23.3.2 Weaver, K. and Yeung, E. *An Analyst's Guide to the Investigation of Clandestine Laboratories*, 3rd edition. Health Protection Branch, Ontario Region Health Canada, 1995.
- 23.3.3 *Clandestine Lab Basic Guide*, presented at the 12th Annual Clandestine Laboratory Investigating Chemists Training Seminar, 2002.
- 23.3.4 Ely, Roger, *et al.* *A Review of the Syntheses and Analyses of Phenyl-2-propanone, Amphetamine, and Methamphetamine*. Clandestine Laboratory Investigating Chemists, 1995.
- 23.3.5 Clandestine Laboratory Investigating Chemists monographs.
- 23.3.6 Strike. *Total Synthesis II*, San Antonio, TX: Panda Ink, 1999.
- 23.3.7 Uncle Fester. *Advanced Techniques of Clandestine Psychedelic & Amphetamine Manufacture*. Port Townsend, WA: Loompanics Unlimited. 1998.
- 23.3.8 Code of Virginia § 18.2-248.
- 23.3.9 Christian, Donnell R., Jr. *Forensic Investigation of Clandestine Laboratories*. CRC Press. 2004.
- 23.3.10 <http://www.dfs.virginia.gov/laboratory-forensic-services/controlled-substances/meth-labs/>
- 23.3.11 Angelos, S.A. et al. "The Identification of Unreacted Precursors, Impurities, and By-Products in Clandestinely Produced Phencyclidine Preparations", *Journal of Forensic Sciences*, 35(6), 1990, pp.1297-1302.
- 23.3.12 Skinner, H. F. "Methamphetamine Synthesis Via Hydroiodic Acid/Red Phosphorous Reduction of Ephedrine", *Forensic Science International*, Vol. 48, 1990, pp. 123-134 (found in CLIC: A Review of Syntheses and Analyses of Phenyl-2-Propanone, Amphetamine, and Methamphetamine. Vol. 1).
- 23.3.13 Person, E.C., Knops, L.A., Northrop, D.M., "One-Pot Methamphetamine Manufacture", *Journal of the Clandestine Laboratory Investigating Chemists Association*, Vol. 14, Number 2, April 2004, p. 14-15.
- 23.3.14 Ely, R. A. and McGrath, D. C., "Lithium-Ammonia Reduction of Ephedrine to Methamphetamine: An Unusual Clandestine Synthesis," *Journal of Forensic Sciences*, JFSCA, Vol. 35, No. 3, May 1990, pp 720-723.
- 23.3.15 Bremer, N. and Woolery, R. J., "The Yield of Methamphetamine, unreacted Precursor and Birch By-Product with the Lithium-Ammonia Reduction Method as Employed in clandestine Laboratories", *MAAFS Newsletter*, Fall 1999, pp 8-16

23.4 Assignments

23.4.1 Study questions and practical exercises

23.5 Study Questions

23.5.1 Describe the difference between a controlled precursor and List 1 or 2 chemicals.

23.5.2 Define the following terms:

- Precursor
- Byproduct
- Catalyst
- Limiting reagent

23.5.3 Explain how an analyst should sample a liquid with three layers.

23.5.4 Discuss the importance of working closely with prosecutors and officers to decide the amount of analyses necessary.

23.5.5 Review the Department's Clan Lab submission guidelines. Discuss the following:

- What items should/should not be submitted?
- What items will be analyzed?
- What weight thresholds are important in the manufacturing charges in Virginia?
- How should submitted items be packaged?

23.5.6 List chemicals and starting materials which would indicate the various syntheses of PCP and methamphetamine. What byproducts would be expected from these syntheses and why?

23.5.7 Discuss the types of analysis that may be necessary when the charge listed is Code of Virginia § 18.2-248 (J). Which compounds listed would be analyzed in the Controlled Substances section and which would be transferred to the Trace Evidence section?

23.6 Practical Exercise (optional due to availability of reagents/starting materials and laboratory safety)

23.6.1 Perform a synthesis procedure that is commonly encountered in clandestine laboratories (either methamphetamine or PCP is recommended).

23.6.1.1 Take samples during the reaction process to monitor the progress.

23.6.1.2 Determine the yield of the reaction.

23.6.1.3 Attempt to identify all compounds in the product mixture.

23.7 Mode of Evaluation

23.7.1 Completion of the study questions

24 FORENSIC LAB SPECIALISTS**24.1 Introduction**

Forensic Lab Specialists (FLS) provide important support to Forensic Scientists in the laboratory. Typically FLS perform duties including, but not limited to the following:

- 24.1.1 Prepare solutions, reagents and standards
- 24.1.2 Participate in the quality assurance/quality control program
- 24.1.3 Maintain inventory of expendable supplies, reagents and materials
- 24.1.4 Perform routine maintenance of instrumentation and equipment
- 24.1.5 Perform general housekeeping duties (e.g., cleaning glassware, removing sharps waste)
- 24.1.6 Transfer sealed evidence
- 24.1.7 Under close supervision, perform routine procedures in the analysis of casework.

24.2 Training Outline

- 24.2.1 Instruction will be provided to the FLS by directed study, demonstration by the trainer and observation of the trainee. All tasks are performed under the direction of the trainer until the training segment is completed.
- 24.2.2 Reference information for the topics below can be found in other sections of this manual, the Controlled Substances Procedures Manual (CSPM) and other Department manuals. The specific locations are noted by section numbers in parentheses by the topic.
- 24.2.3 Orientation
 - 24.2.3.1 Introduction to the local facility, staff and how the FLS fits into the Department of Forensic Science (DFS).
 - 24.2.3.2 Description of the FLS position and clarification of duties.
 - 24.2.3.3 Coverage of the following:
 - Quality Manual
 - Controlled Substances Procedures Manual with emphasis on the Quality Assurance Section
 - Controlled Substances Training Manual
 - Regional Operating Procedures
 - Safety Manual, to include Bloodborne Pathogen and Chemical Hygiene training
 - Organizational Chart of DFS
 - 24.2.3.4 Introduction of the technical capabilities of all the DFS laboratories and how it fits into the Virginia law enforcement system.
 - 24.2.3.5 Introduction to the LIMS system.

24.2.4 Laboratory and Glassware

24.2.4.1 Objectives

- 24.2.4.1.1 To familiarize the FLS with the basic cleaning procedures for laboratory areas, hoods and glassware
- 24.2.4.1.2 To train the FLS on the proper operation of the laboratory glassware washer
- 24.2.4.1.3 To familiarize the FLS with the safety requirements of the laboratory and available personal protective equipment (PPE)
- 24.2.4.1.4 To instruct the FLS on the proper handling and maintenance of compressed gas cylinders
- 24.2.4.1.5 To familiarize the FLS with the proper disposal of Biohazard and Sharps waste

24.2.4.2 Mode of Instruction

Demonstrations by the TC or designee

24.2.4.3 References

- 24.2.4.3.1 DFS Safety Manual
- 24.2.4.3.2 Operations manual for glassware washer

24.2.4.4 Mode of Evaluation

Observation of the FLS by the trainer

24.2.5 Reagent Preparation

24.2.5.1 Objectives

- 24.2.5.1.1 To familiarize the FLS with the preparation of color test reagents and thin layer chromatography (TLC) baths and sprays
- 24.2.5.1.2 To familiarize the FLS with the preparation of standards and solutions
- 24.2.5.1.3 To familiarize the FLS with the Quality Assurance schedule and documentation

24.2.5.2 Mode of Instruction

Demonstrations by the TC or designee

24.2.5.3 References

- 24.2.5.3.1 *CSPM* Color Test Section
- 24.2.5.3.2 *CSPM* Thin Layer Chromatography Section
- 24.2.5.3.3 *CSPM* Quality Assurance Section

24.2.5.4 Mode of Evaluation

Observation of the FLS by the trainer

- 24.2.6 Balances
 - 24.2.6.1 Objectives
 - 24.2.6.1.1 To familiarize the FLS with the operation of laboratory balances
 - 24.2.6.1.2 To familiarize the FLS with balance calibration checks and quality assurance
 - 24.2.6.2 Modes of Instruction
 - 24.2.6.2.1 Presentations and demonstrations by the TC or designee regarding balances to include general use, leveling and cleaning
 - 24.2.6.2.2 Presentation and demonstration regarding the quality assurance of balances
 - 24.2.6.2.3 Study Questions (6.5.1 (except the UoM terms), 6.5.2, 6.5.3, 6.5.4, 6.5.7, and 6.5.8.)
 - 24.2.6.3 References
 - 24.2.6.3.1 Balance Manufacturer's operating manual
 - 24.2.6.3.2 CSPM Quality Assurance Section
 - 24.2.6.4 Modes of Evaluation
 - 24.2.6.4.1 Observation of the FLS by the trainer, including quality assurance of balances
 - 24.2.6.4.2 Completion of the study questions
 - 24.2.6.4.3 Competency test sample. Receive a previously weighed sample from the TC or designee
- 24.2.7 Ordering/Stocking
 - 24.2.7.1 Objective
 - To familiarize the FLS with routine ordering practices for consumable laboratory supplies
 - 24.2.7.2 Mode of Instruction
 - Demonstrations by the TC or designee
 - 24.2.7.3 Reference
 - 24.2.7.3.1 DFS Administrative Policies
 - 24.2.7.4 Mode of Evaluation
 - Observation of the FLS by the trainer
- 24.2.8 Evidence Transfer
 - 24.2.8.1 Objectives
 - 24.2.8.1.1 To familiarize the FLS with the fundamentals of evidence security and transfer procedures in order for the FLS to handle sealed evidence

24.2.8.1.2 To familiarize the FLS with the LIMS system

24.2.8.2 Modes of Instruction

24.2.8.2.1 Demonstration by the TC or designee regarding proper chain of custody and evidence handling procedures. The FLS should observe the trainer transferring evidence for a minimum of two weeks.

24.2.8.2.2 Demonstration by the TC regarding the proper use of the LIMS system.

24.2.8.2.3 Study Questions (see Section 5.5.1 – 5.5.5)

24.2.8.3 References

24.2.8.3.1 *Quality Manual*, Department of Forensic Science, Evidence Handling section

24.2.8.3.2 LIMS system manual

24.2.8.4 Modes of Evaluation

24.2.8.4.1 Observation of FLS by trainer

The trainer should observe the FLS transferring evidence while maintaining appropriate documentation for a minimum of two weeks.

24.2.8.4.2 Written Examination

The content of the questions will be based on both the study questions and references.

24.2.9 Color Tests

24.2.9.1 Objective

To familiarize the FLS with color tests to enable them to perform quality assurance and assist examiners with casework under supervision

24.2.9.2 Mode of Instruction

Demonstration by the trainer regarding proper color test procedures

24.2.9.3 References

24.2.9.3.1 *CSPM*, Color Tests section

24.2.9.3.2 *CSPM*, Marijuana section

24.2.9.4 Mode of Evaluation

Observation of FLS by trainer

24.2.10 Thin Layer Chromatography (TLC)

24.2.10.1 Objective

To familiarize the FLS with the practice of TLC to enable them to perform quality assurance and assist examiners with casework under supervision

24.2.10.2 Mode of Instruction

Demonstration by the trainer regarding proper TLC procedures

24.2.10.3 Reference

24.2.10.3.1 *CSPM*, Thin Layer Chromatography section

24.2.10.4 Mode of Evaluation

Observation of FLS by trainer

24.2.11 Gas Chromatography (GC)

24.2.11.1 Objective

To familiarize the FLS with the practice of GC to enable them to perform quality assurance and assist examiners with casework under supervision

24.2.11.2 Mode of Instruction

Demonstration by the trainer regarding proper GC procedures

24.2.11.3 Reference

24.2.11.3.1 *CSPM*, Gas Chromatography section

24.2.11.4 Mode of Evaluation

Observation of FLS by trainer

24.2.12 Extractions

24.2.12.1 Objectives

24.2.12.1.1 To familiarize the FLS with extraction methodologies used in standard preparation

24.2.12.1.2 To familiarize the FLS with extraction methodologies used in sample preparation

24.2.12.2 Mode of Instruction

Demonstrations by the TC or designee regarding proper extraction procedures

24.2.12.3 References

24.2.12.3.1 *CSPM*, Psilocybin and Psilocyn section

24.2.12.3.2 *CSPM*, Cathinone

24.2.12.4 Modes of Evaluation

24.2.12.4.1 Observation of FLS by trainer

24.2.12.4.2 Competency test sample(s)

24.2.12.4.3 Receive a previously validated sample from the trainer for each type of extraction

24.2.13 Gas Chromatography/Mass Spectrometry (GC/MS)

24.2.13.1 Objectives

24.2.13.1.1 To familiarize the FLS with the practice of GC/MS to enable them to perform quality assurance and assist examiners with casework under supervision.

24.2.13.1.2 To familiarize the FLS with the ChemStation software.

24.2.13.2 Modes of Instruction

24.2.13.2.1 Demonstration by the trainer regarding proper GC/MS procedures

24.2.13.2.2 Demonstration of liner cleaning and preparation by the trainer

24.2.13.3 References

24.2.13.3.1 *CSPM*, GC/MS Section

24.2.13.3.2 *CSPM*, GC Section 10.3.14 (liner cleaning)

24.2.13.4 Mode of Evaluation

Observation of FLS by trainer

24.2.14 Fourier Transform Infrared Spectroscopy (FTIR)

24.2.14.1 Objectives

24.2.14.1.1 To familiarize the FLS with the practice of FTIR and associated accessories to enable them to perform quality assurance and assist examiners with casework under supervision.

24.2.14.1.2 To familiarize the FLS with the OMNIC software.

24.2.14.2 Modes of Instruction

24.2.14.2.1 Demonstration by the trainer regarding proper FTIR sampling procedures

24.2.14.2.2 Nicolet OMNIC Tutorial

24.2.14.2.3 Study questions

24.2.14.2.4 Practical exercises

24.2.14.3 Reference

24.2.14.3.1 *CSPM*, Infrared Spectroscopy section

24.2.14.4 Study Questions

24.2.14.4.1 What is Infrared Spectrophotometry?

24.2.14.4.2 Draw a block diagram of the FTIR and describe the functions of the major components.

24.2.14.4.3 What is meant by the “fingerprint region” of an IR spectrum?

24.2.14.4.4 List advantages and disadvantages of ATR versus traditional bench FTIR.

24.2.14.4.5 Describe how spectra run for an examiner are labeled.

24.2.14.5 Practical Exercises

24.2.14.5.1 Obtain the following samples from the trainer and run on the ATR accessory and using a KBr pellet. Print results according to trainer instructions including a library search.

- Cocaine base
- Cocaine HCl
- Procaine HCl
- Amoxicillin

24.2.14.5.2 Obtain the following samples from the trainer and run on the ATR accessory. Perform any clean-up procedures indicated by the trainer. Provide printed data to the trainer for evaluation of data and documentation practices.

- Gamma butyrolactone
- 3,4-MDMA HCl
- Ephedrine
- Pseudoephedrine
- Methamphetamine
- Phentermine
- Sugar
- Sodium bicarbonate
- Cocaine base / procaine mixture
- Cocaine HCl / lactose mixture

24.2.14.6 Modes of Evaluation

24.2.14.6.1 Observation of FLS by trainer

24.2.14.6.2 Completion of study questions

24.2.14.6.3 Competency test sample

Receive a previously validated sample from the TC or designee

24.2.15 Tablets and Capsules

24.2.15.1 Objective

To familiarize the FLS with available references for pharmaceutical identifiers

24.2.15.2 Mode of Instruction

Demonstrations by the TC or designee

24.2.15.3 Reference

24.2.15.3.1 *CSPM*, Pharmaceutical Identifiers section

24.2.15.4 Mode of Evaluation

Observation of FLS by trainer

24.3 Completion of Training

- 24.3.1 The training will be considered complete when the FLS has completed all of the sections in the training manual, which are required by the TC, and been evaluated by the TC or his designee.
- 24.3.2 The checklist for the FLS training will be initialed and completed for each area assigned by the TC and any other personnel who assisted in the training in accordance with the Department Quality Manual.
- 24.3.3 When the training is complete the TC will notify all supervisors, the Chemistry Program Manager, the QAC and training records will then be stored in accordance with the Department Quality Manual.
- 24.3.4 If the FLS cannot meet the expected criteria during an expected period of time for training, steps will be taken to effect appropriate action.

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Appendix A – List of Known Drugs

- Cocaine HCl
- Cocaine Base
- Lidocaine
- Benzocaine
- Procaine
- Tetracaine
- Amphetamine
- Methamphetamine
- Methylphenidate
- Phentermine
- Ephedrine
- Pseudoephedrine
- Caffeine
- Theophylline
- Secobarbital
- Butalbital
- Acetaminophen
- Ibuprofen
- Aspirin
- Salicylamide
- Dextromethorphan
- Fentanyl
- Testosterone Propionate
- Nandrolone
- Substituted Cathinones
- Quinine
- Diphenhydramine
- Morphine
- Heroin
- Oxycodone
- Hydromorphone
- Codeine
- Hydrocodone
- Methadone
- Meperidine
- Guafenesin
- Alprazolam
- Diazepam
- Phencyclidine
- LSD
- LAMPA
- Mescaline
- Psilocin
- Psilocybin
- Bufotenine
- 3,4-MDA
- 3,4-MDMA
- 4-Bromo-2,5-dimethoxyphenethylamine
- Ketamine
- Benzylpiperazine
- Amoxicillin
- Dimethyl Sulfone
- Cannabimimetic Agents